MECHANICS APPLIED TO THE RACE HORSE

(Une Foulée de Galop de Course)

BY

COLONEL H. COUSTÉ

JOHN A. SEAVERNS

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MECHANICS APPLIED TO THE RACE HORSE.

(Une Foulée de Galop de Course)

SECOND EDITION.

WITH A STUDY OF THE CONSTRUCTION AND FUNCTIONS OF THE HIND LEGS.

REPLIES TO CRITICISMS.

BY

COLONEL H. COUSTÉ

TRANSLATED
BY
E. B. CASSATT

PARIS, 1914
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This

HIPPOLOGICAL STUDY

is

respectfully dedicated

to

GENERAL DUPARGE

Permanent Inspector-
General of Remounts

Translator's Preface.

THERE are few reasoning men in this country who do not realize, after a year of European War, that the horse is one of the most important factors in the equipment of armies. It is unnecessary to detail the efforts made by European Governments to improve the breed of horse in their respective territories. These Governments are so fully alive to the military and commercial importance of the horse that they spend annually vast sums of money in importing English thoroughbreds of the best type for crossing with the mares of their country, thereby producing in large quantities animals capable of serving them either under the saddle or in harness. The United States Government has begun to realize the importance of this subject and has made a start, whether in the right direction or not, cannot be said as yet.

In requesting Colonel Cousté's permission to translate this very valuable work I was desirous of reaching three classes.

The School of Application for Cavalry at Saumur, in France, is probably the best school in the world of its kind. It is the ambition of every young French Cavalry officer to become a member of the famous Cadre Noir, the affectionate popular name for the Corps des Ecuyers, who are the riding instructors at this school. As there are only twelve members of this Corps it will be seen that not all of the several thousand young officers can attain this ambition, and the fact that Colonel Cousté was an Ecuyer at Saumur would indicate that he was equipped to speak on the highest authority to our fellow-citizens on the subject of equitation and of the type of horse required for good equitation, both civil and military, and

on this portion of the subject he ought to interest all American Cavalry and Artillery officers.

The Remount Department of the French Army is one of the best. Colonel Cousté has commanded a region of this Remount Department. He should, therefore, appeal especially to the officers of our embryo Remount Department, to the officers of the Bureau of Animal Industry, at Washington, and through them to the horse-raising population of our country.

The third and by far the most important class which I desire to reach is the racing man and the breeder of thoroughbred horses, and I think that a glance at this interesting work will convince the racing man that Colonel Cousté knows what he is talking about. He did me the honor to visit my modest racing establishment and it was not five minutes before I discovered that he was an expert on conformation, pedigrees and all matters pertaining to racing in France, England and the United States.

I say that the racing-man is the most important of the three classes mentioned above, because I agree thoroughly with Colonel Cousté as to the evil effects produced upon the model of the thoroughbred horse by premature two-year-old racing and by short-distance racing, and it is the racing-man who is primarily responsible for changes in the conditions of racing and, hence, in the model of the race-horse, and he is responsible ultimately for the model, gaits, quality and stamina of the commercial horse of this country.

E. B. Cassatt.

January, 1916.

Chesterbrook Farm, Berwyn, Pennsylvania.

MECHANICS APPLIED TO THE RACE HORSE.

(Une Foulée de Galop de Course.)

SECOND EDITION.

Preface to the Second Edition.

WHEN " Une Foulée de Galop de Course " appeared in 1909, our little pamphlet immediately found partisans and detractors: it pleased and it displeased. A number of horsemen and hippologists did not hesitate to tell the author of the pleasure they had experienced in finding a convincing reply to the troublesome question they often had asked themselves, " Why is it that there has been such a modification in a breed perfected by selection for two hundred years by tests at the gallop, a gait essentially that of the saddle horse; why does this breed differ so manifestly from the model of the saddle horse?"

The sporting press, on the contrary, and all those who consider that the prosperity of racing is a sign that its progress is in the right direction, made many reservations in their appreciation and, while promising to discuss in detail the various arguments advanced in the pamphlet, entrenched themselves behind a tradition still respected, since for two centuries, all the efforts of breeders had had for object the production of a Derby or St. Leger

winner, and since the winners of these classics, which could not be called sprint races, had always been the animals most desired for breeding purposes.

In spite of these promises and to our great regret, the critics, either through disdain or from the difficulty of finding arguments, kept silence and "La Foulée" received no further mention.

Still there had arisen a latent trend of thought with which perhaps our little study had something to do, a trend in favor of the stayer.

On December 12, 1911, at the annual banquet of the Gimcrack Club, Lord Villiers (now Earl of Jersey), representative of the English Jockey Club, denounced the sprinter. Soon afterward it was decided that there should be, in England, no races shorter than five furlongs, even for two-year-olds. This same rule was adopted this year in Belgium. Finally the French Jockey Club increased from 30,000 francs to 100,000 francs the added money in the Prix du Cadran (2½ miles) and made this an international race.

These are precious symptons which justify the hope that an idea is germinating which will tend toward the greatest good of the Thoroughbred and the more intelligent breeding of the saddle horse.

But, to return to our pamphlet, it was easy to recognize that it was lacking in one important point. It touched only lightly upon and treated only incidentally the question of the hind quarter. This question is, however, of great importance; in the first place, because in every quadruped, a necessary harmony exists between the fore hand and the hind quarter; then further because any modification, either of the fore hand or of the hind quarter establishes in the mechanism compensations or substitutions which it is indispensable to bring to light; finally because, in our opinion, hippologists and horsemen

have given voice to various and often divergent opinions upon the best model of croup, without supporting their preference by any convincing reasons.

We propose in this second editon to remedy this serious defect, using for the study of the hindquarter the same minutious methods employed for that of the fore hand.

Perhaps it would have been logical to combine our new study with our first work, thus forming a harmonious and complete whole, but we thought that certain of our demonstrations were a little involved in character, that it was wiser not to tire the reader's attention without respite; therefore we found it preferable to include in our second edition the original, just as it had already been presented, and to complete it by a second study.

To what we theoretically shall expound, we shall add examples drawn from recent racing events and we shall attempt an explanation of the facts.

Finally, however, summary, and if we may say it, however feeble the criticism has been, we shall devote a chapter to its refutation so as to dissipate in the mind of the reader even the very shadow of a doubt.

MECHANICS APPLIED TO THE RACE HORSE.

(Une Foulée de Galop de Course.)

I

THE Thoroughbred is what racing makes him. Our saddle horses are what they are made by the Thoroughbred; hence the capital interest attaching to the the minute analysis of the galloping stride, the smallest variations of which may have the most serious and often the most unexpected results.

In all times the gaits of the horse have been the object of the study of horse lovers. Without going so far back as Solleysel, Bourgelat, Vincent and Goiffon, one can cite the names of Raabe, Lenoble du Teil, Lecoq, who have made remarkable researches on this subject; but it is Muybridge's instantaneous photographic experiments and Marey's chrono-photographic series which caused a decided advance to be made in knowledge of the subject and which permitted the foundations to be laid of the theories now accepted.

The raising and grounding of the feet have been determined with great precision; the time of support and suspension has been calculated, the oscillations of the center of gravity and the pressure of each leg on the ground, etc., have been measured. One point, however, seems to us to have remained in obscurity; we refer to the velocity of translation of the body during a stride at the gallop.

Reasoning shows clearly that this velocity is far from being uniform.[1]

The hind foot which forms the first step of the stride strikes the ground only with the remaining volocity of the preceding stride; as it strikes, a part of this remaining momentum should be neutralized by the reaction of the ground; the whole of the first phase of the rotation of the body around this hind foot should therefore be executed with a relatively low velocity. But as soon as the hind leg has passed the vertical it should begin to contribute its propulsive force and the velocity should increase. It should tend to diminish in the second step of the stride when the other hind foot is grounded; it should reach its maximum as soon as the two hind legs shall have combined their propulsive effort during the formation of the diagonal base and until the third step or the grounding of a fore foot. From this third step on, the velocity should decrease during the whole time of rotation of the body around the fore feet and especially at the fourth step when the base becomes unipedal on one of the fore feet and when part of the motion is absorbed by the reaction by the earth and also by the work of compression of the spring which is to produce the period of suspension. This last phase of the stride, therefore, also should be executed at reduced speed.

It was interesting to verify by experiment these theoretical conceptions. To do this we used the series of

[1]Although the gait of the gallop is well known, it will perhaps not be useless to recall its mechanism here.

The racing gallop is a gait of four steps followed by a period of suspension.

Suppose the horse to be galloping on the left foot; the first step is the grounding of the right hind foot; the second the grounding of the left hind foot; the third, the grounding of the right fore foot, and the fourth, the grounding of the left fore foot; then comes the period of suspension and the series is repeated in the same order.

The supports are in the following order:

Unipedal right posterior
Bipedal posterior
Bipedal right diagonal
Bipedal anterior
Unipedal left anterior

chronophotographic pictures given by Lieutenant-Colonel Gossart in his work, "Les Allures du Cheval"; these pictures which follow one another at intervals of 1/25 seconds permit the recording of the raising and grounding of each foot with an error of less than 1/50 second, a sufficient approximation.

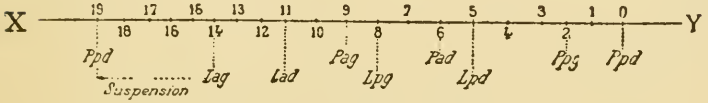


FIG. 1—A GALLOPING STRIDE ON THE LEFT FOOT.

Ppd—Grounding of right hind foot.
Ppg—Grounding of left hind foot.
Pad—Grounding of right fore foot.
Pag—Grounding of left fore foot.
Lpd—Raising of right hind foot.
Lpg—Raising of left hind foot.
Lad—Raising of right fore foot.
Lag—Raising of left fore foot.

We projected upon a horizontal line X Y (Fig. 1) the position of a very conspicuous point of the body (the girth, clearly defined in white on the pictures). The space between two projections evidently shows the distance traversed in the unit of time, that is to say, the velocity. These projections are numbered 1, 3, 5, 7, 9.....19. We assumed that between two consecutive projections the velocity of translation was constant and we halved the spaces included between two projections, which gave us the series of number 2, 4, 6, 8.....18. The divisions of the whole series 1, 2, 3, 4.....19 correspond therefore to fiftieths of a second, and we were able to show with regard to each of them and with a sufficient approximation the raising and grounding of the several feet.

It is seen that the stride is completed 19/50 seconds. A glance at figure 1 suffices to show that the distances

travelled in the unit of time are sensibly different; to make these differences in velocity the more easily appreciable we have constructed a curve of velocities (Fig. 2).

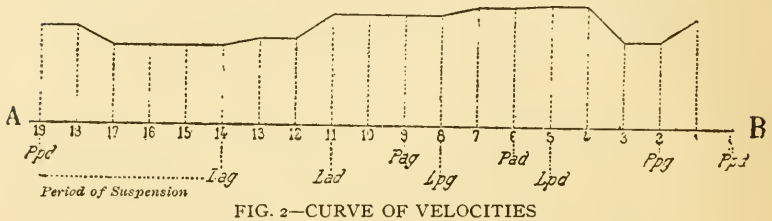


FIG. 2—CURVE OF VELOCITIES

The line A B is divided into 19 equal parts and we have taken upon ordinates erected at the division points, distances proportional to the velocity at each 1/50 second (ordinate 1, Fig. 2) is equal to four times the distance 0—1 (Fig. 1); ordinate 2 (Fig. 2) is equal to four times the distance 2—3 (Fig 1) and so on. By joining the summits of these ordinates, we obtain the curve of velocities.

It is seen that, at Epoch 2, the grounding of the left hind foot slightly diminishes the velocity; it remains relatively slow at Epoch 3, while the left hind leg is rotating, then it quickly reaches its maximum at Epoch 4, when the latter leg joins its propulsive force to that of the right hind leg. This maximum is maintained practically until Epoch 6, when the grounding of the right forefoot retards it slightly; another diminishing of velocity is produced at Epoch 8 when the left hind foot is raised. The curve then reveals a really peculiar fact: the velocity remains constant from Epoch 8 to Epoch 11, although the left fore foot is grounded at Epoch 9; now it must be noted that during this period both hind legs are in the air and the translative impulse is fed only by the right fore leg which acts after the manner of a pole pushing a boat along. This action is made appreciable at Epoch 11 when the right fore foot is raised and when the uni-

pedal left anterior support begins; the velocity falls off rapidly and reaches its minimum at Epoch 14 when the left fore foot is raised. The period of suspension lasts from Epoch 14 to Epoch 19; it is performed at minimum velocity with an appreciable increase at the end when the vertical component which has raised the horse from the ground is neutralized and when the body is brought back toward the ground by force of gravity.

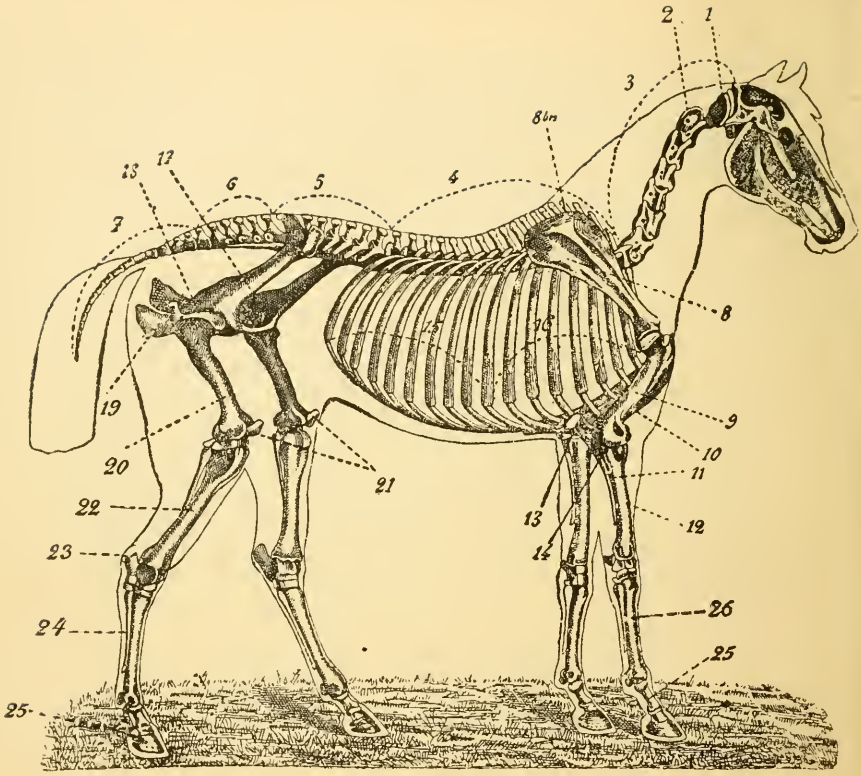
Summing up and neglecting too delicate variations, the speed is rapid in the middle of the stride (from Epoch 4 to Epoch 11); it is slow at the beginning (from 1 to 3) and at the end (from 12 to 19). This fact can also be expressed by saying that, during the period of suspension and the period of rotation of legs in supporting positions, the velocity of translation is from a third to a sixth slower than during the formation of the diagonal support (from the third to the fourth step of the stride).

Reasoning is therefore confined by facts.

It is evident that the velocity of the gallop would be increased if it were possible materially to reduce the duration of the periods during which the velocity is at its minimum. This length of time is not a negligible quantity, since in the example just given it is 12/19 of the total duration of the stride.

But the period of suspension is independent of the will of the horse; in each animal it is a function of his own coefficient of elasticity. An elastic ball thrown with a given force against ground of a given consistance will rebound to a height absolutely independent of the will of the thrower. It will be seen later (footnote, p. 24) how this comparison may be too fixed.

In the same way the amplitude of the oscillations of the legs in their supporting positions depends upon the angle at which the legs are grounded, and it is quite certain that at a racing pace, when the horse is doing all he knows how, the legs will approach the ground at the



THE SKELETON

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M. DE GASTE

NOMENCLATURE OF THE SKELETON

1—Atlas or First Cervical Vertebræ.
2—Axis.
3—Cervical Vertebræ.
4—Thoracic or Dorsal Vertebræ.
5—Lumbar Vertebræ.
6—Sacral Vertebræ.
7—Caudal Vertebræ.
8—Scapulum (Shoulder).
8 bis—Scapular Cartilage.
9—Humerus (Arm).
10—Sternum.
11—Radius (Fore Arm).
12—Ulna (Cubitus).
13—Olecranon (Elbow).
14—Elbow Joint.
15—The Eight Ribs.
16—The Ten False Ribs.
17—Ilium.
18—Coxo-Femoral Joint.
19—Ischium.
20—Femur (Thigh).
21—Stifle Joint (Patella).
22—Tibia.
23—Calcaneum (Hock).
24—Metatarsus.
25—Phalanges.
26—Metacarpus.

smallest angle permitted by the conformation of the animal.

It is then the conformation of the horse that must be modified in order to reduce the duration of the periods of minimum velocity.

Let us examine how this is to be done.

Let us first consider the fore hand upon which depends the period of suspension.

Again we must seek the solution in chronophotography.

Figure 3 is a sketch representing the chronophoto-

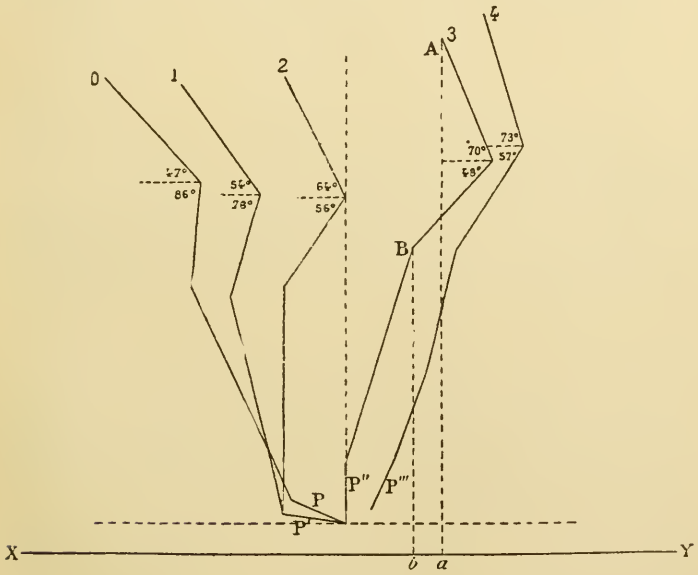


Fig. 3 (1).

[1]It is interesting to study the play of the phalanges during the rotation of the leg. At the time of grounding the phalangian lever occupies the position P, at an angle acute to the horizontal; this angle closes and the lever takes the position P', which it maintains while the leg is in positions 1 and 2; the angle then quickly opens to a right angle; the phalangian lever is vertical at position P''' when the leg is at position 3.

It is to be regretted that the Marey plates do not show an intermediate position of the leg between positions 3 and 4; it would

graphs of a fore leg on the ground at the gallop (plate by Marey and Pagès).

There are five positions of the leg numbered 0, 1, 2, 3, 4.

At position 0 the foot strikes the ground, at 4 is has just left the ground.

It is seen that during the whole time of rotation, the scapulo-humeral angle is closing and has the following values:

Values of the Scapulo-Humeral Angle.

Position 0	133°
" 1	130°
" 2	120°
" 3	118°

At position 4, when the foot leaves the ground, the angle quickly opens to 130°.

But the closing of the scapulo-humeral angle is accomplished in a very pecular way: during the whole rotation the scapulum continues to rise from the horizontal and its inclination is as follows:

---

correspond to the precise movement when the arm rises sharply toward verticality to cause the lifting of the fore hand.

At this moment reasoning would show that all of the leg below the arm should be a rigid column, and consequently should be without angles; if not, the effort of the arm would tend to close the angles and a part of the energy expended by the arm would be lost. For the same reason the contraction of the muscles which support the shoulder must be such that the scapulum shall be motionless in spite of the force exerted by the arm.

It seems clear that the motion of the humerus is controlled by the sterno-humeral muscles, and the longer the lever arm by which these muscles act the easier the movement. The runner with a relatively long humerus should therefore have a long period of suspension. The length of the arm appears to be diminishing in our present day Thoroughbred. According to M. de Gasté, the proportional length of shoulder to arm is 1.94 to 1 with the present Thoroughbred; according to the measurements of the horse *Fitz-Gladiator*, it is 1.55 to 1; in the trotter it is 2.04 to 1. (de Gasté.)

The rotation of the phalangian lever begins and ends at the same time as that of the leg, but it presents the peculiarity that it has in the beginning a movement in the opposite direction; this lever passes from P to P", and again passes through P to P"'. The distance P P' depends upon the elasticity of the pastern and that is a function of its length. We must, therefore, shorten the pastern if we hasten the rotation of the leg in order that the rotation of the phalanges shall end with that of the leg. The pastern of the present day Thoroughbred is shortening, hence the frequency and seriousness of bone troubles.

Inclination of the Scapulum to the Horizontal.

Position	0	47°
"	1	54°
"	2	64°
"	3	70°
"	4	73°

while the humerus is closing its angle during the first four positions. This angle is as follows:

Inclination of the Humerus to the Horizontal.

Position	0	86°
"	1	76°
"	2	56°
"	3	48°

At position 4, when the foot leaves the ground the humerus quickly comes back toward the vertical, forming an angle of 57° with the horizontal.

Thus, so far as the shoulder and arm are concerned, the work of shock absorption and of compression of the spring which is to produce the period of suspension is characterized by approach to verticality on the part of the shoulder and by approach to horizontality on the part of the arm and this double movement in opposite angular directions continues until the critical movement when, equilibrium being about to be lost and the foot about to leave the ground, the arm rotates suddenly downward and causes projection through the air.

If, in figure 3, we project to the points a and b on X Y, the points A and B, respectively the upper end of the shoulder and the lower end of the arm in position 3, we see that the critical moment when equilibrium is about to be disturbed is when the distance separating the two projections is greater than a b (a having passed b in the forward direction as shown in figure 3).

Now it is evident that if the initial position of the shoulder had been nearer the vertical, this critical moment would have come sooner; just as it would have if the initial position of the arm had been farther from verticality, and all the more so if at the same time the shoulder had been more upright and the arm more sloping.

The rotation of the leg would not have had the amplitude of that in the sketch (Fig. 3), the absorption of the shock would have been less complete, and there would not have been so perfect a preparation for the period of suspension; for although we have no information as to the conformation of the horse used by Messrs. Marey and Pagès in making their plates, we have no right to suppose that he did not use all the means permitted by his conformation for executing this rotation as perfectly as he could.

We are thus led to conclude that obliquity of shoulder and uprightness of arm give the leg a wide angle of rotation, favor shock absorption and the extent of the period of suspension, and that consequently the opposite arrangement of these radii reduces the angular extent of rotation, absorbs vital force, diminishes the co-efficient of elasticity and shortens the period of suspension.

The "sprinter" should then have a relatively upright shoulder and an arm nearly horizontal.

What should his hindquarter be?

The object is to increase speed, consequently to reduce the angle of oscillation of the hind legs; but it is necessary also to harmonize the action of the hindquarter with that of the forehand.

Observe that as the arm becomes less upright the height at the withers decreases. We shall see later on in comparing the measurements of very different animals that there are variations of 20° and more in the slope of the arm; variations carrying with them differences at

the withers of from two and a quarter to two and a half inches. In order that the horse built in front for a sprinter shall keep his equilibrium, it will be necessary to lower his hind quarter and consequently to make his femur and his tibia come closer to the horizontal.

But this change of the slope of the femur gives the ischio-femoral muscles an insertion very oblique and consequently disadvantageous; to correct it we must lower the ischium, and to that end the hip must be made to rotate downward on a horizontal axis perpendicular to the median plane of the body. The ischio-femoral muscles and ischio-tibials which are the most powerful muscles of the organism and which play a preponderating role in propulsion will, by this fact, be shortened, and that is an advantage, from the point of view of speed.

The greater the propulsion the more rapid will be the rotation of the hind leg. Now it is evident that for a given nervous impulse a short muscle will arrive more quickly at its maximum contraction than a long muscle. The propulsive force will then be applied more quickly with a sloping croup and short ischio-tibials than with a horizontal croup and long ischio-tibials.

The sprinter then, whose theoretical model has just been drawn for us, is not a theoretical animal; he exists; one can even say he exists almost entirely alone at the present time. Short distance races have been responsible for making this conformation the common conformation of the race.

At a standstill the model appears as follows: Shoulder upright, arm very much inclined, elbow to the rear, pasterns rather short than long; steep croup, and sloping femur, stifle to the front, rump short and rounded; muscles much in evidence. The general appearance is short and the four feet are close together.

In action the gallop is quick with rapidly repeated strides; the velocity is extreme.

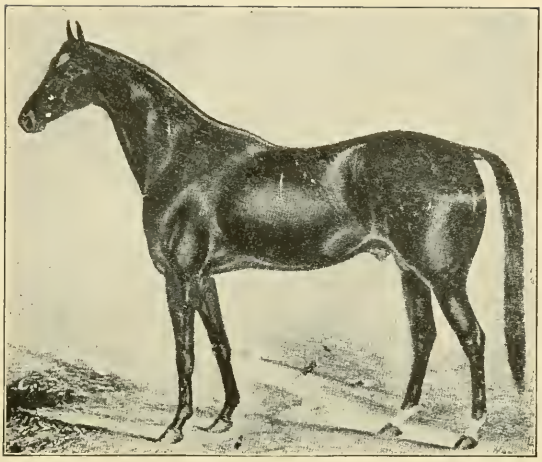
The speed is extreme, but it is produced by a succession of tiring efforts, and the resources of the horse cannot take him beyond a short distance. It must not be forgotten that the period of suspension is a period of relative rest, and it is this peculiarity which permits animals built for stayers to sustain their effort over long distances.

* * *

In an " Etude hippique " which appeared in 1904 under the pseudonym of " Sincère," a distinguished officer of the Breeding Department showed that the modification of race programs had little by little destroyed the supremacy of the staying families and had brought about that of animals presenting a model better adapted to extreme speed over short distances. " Sincère " pointed out the evolution, but he did not show that it was fatal. Although he appealed to the evidence of horsemen old enough to be able to judge by comparison, and although he pointed out the extraordinary differences between the old engravings and the portraits of the present-day horse, we fear that in spite of him many are incredulous; some because they are too young to be able to compare and because the lamentations of age have the privilege of being but slightly echoed by youth; others, although old enough to have an opinion, are incredulous because they doubt their own impressions and they ask themselves with anxiety whether it is the horses or themselves that have changed.

It seems to us that the preceding pages should allay all doubts upon the question; it is absolutely true that there exists a special type of sprinter and that this type is tending to become the type of the thoroughbred under the test of short distance racing.

One objection suggests itself, however.



ARISTIDES
Winner of the First Kentucky Derby, 1875
THE OLD TYPE

OLD ROSEBUD
Winner of the Kentucky Derby, 1914
THE NEW TYPE

(Reproduced from 1915 Program of New Louisville Jockey Club)

Certain hippologists have said: "There are two ways of producing speed: first, by short and rapidly repeated strides; second, by long and relatively slow strides. Consequently, short distance races can serve for picking out types corresponding to these two ways of galloping."

This argument is but specious.

However long a stride may be, the gallop resulting from it will still be slower than that which is the result of short rapid strides so long as the average speed of the long stride is less than the average speed of the short stride.

Suppose two horses, of which the one makes a stride of the length F, equal to n strides of the other. But the velocity V of the stride F is less than the velocity V′ of the stride f; we have therefore by hypothesis:

$$F = n\,f$$

On the other hand, $F = Vt$ and $n\,f = V'\,t'$

Therefore, $Vt = V'\,t'$

But since by hypothesis V′ is greater than V, the last equation cannot be true unless t′ is less than t.

So the horse with short and rapid strides will consume less time in covering the distance F than the horse which covers this distance in a single stride.

Therefore the long striding horse must find a means of increasing the average speed of his stride if he is to compete with the short striding horse.

It is evident that he will not increase this average speed by increasing the period of suspension or the period of oscillation of the legs in their supporting positions, since these phases of the stride correspond to minimum speed; he must therefore increase the extent of his diagonal base (between the second or third steps of the gallop), his compass opening, which corresponds with maximum speed.

Let us say right away that the differences of compass

opening between two horses of the same height will never be very much; but the distance which a better shaped horse will have gained as the result of a wider oscillation of his legs in suspension will be lost in time as the result of the wider oscillation of his legs in support.[1]

The sketch (Fig. 4) depicts this fact. It represents a foreleg A B C D which, as the result of wider oscillation in suspension, gains a distance of D′ F at the moment of grounding over a leg of the same stride, A′ B′ C D′.

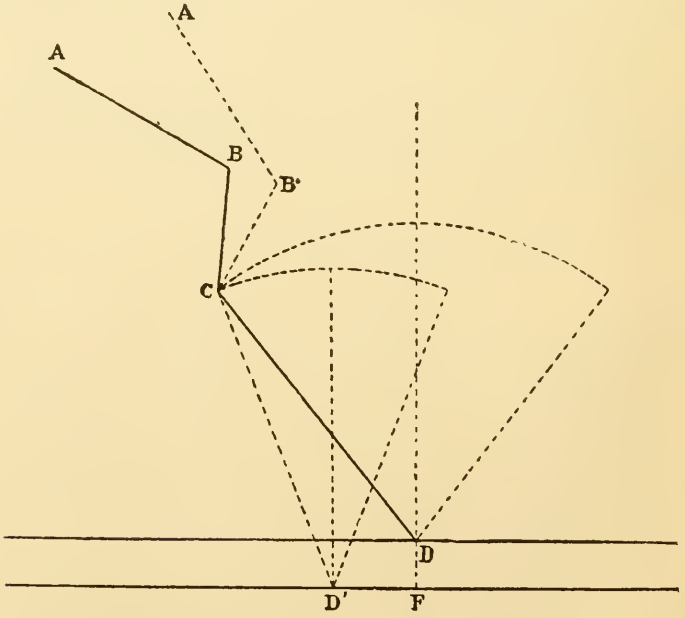


FIG. 4.

[1]It is undeniable that training can, to a certain extent, modify the aptitude of horses; that it can teach them to form the habit of hurrying when they are being prepared for a short race or to extend themselves and cadence their stride during preparation for a long distance race.

In the first case, there is every reason to believe that the horse becomes accustomed to reducing his period of suspension; during this period, indeed, the animal remains near enough to the ground for him to resume contact before the moment when he is forced to by

It is at once seen from the figure that the rotation of the leg A B C D around the point D will take a great deal longer than that of the leg A′ B′ C D′ around the point D′ and will make it lose all the benefit D′ F that it has gained.

The horse with long strides cannot then, by using his mechanism in a normal way, increase the average speed of his stride.

He might increase his speed, not in a continuous way but at the time of a particular effort, by what is called the racing spring (bond de course). In this spring the third step of the gallop is made by the fore leg, only when the corresponding hind leg is already in suspension. It is evident that the distance covered in this way exceeds by a great deal the compass opening of the normal gallop. According to Captain Dumas (Album de Haute Ecole, 1894), "the horse gains almost a yard (at maximum speed) and the following period of suspension is diminished," conditions doubly favorable to speed.

It is probable that long striding animals, which nevertheless shine over short distances, have recourse to this proceeding. But it is an extremely fatiguing proceeding and one that reduces them to the role of sprinter when their mechanism, if normally used, would make them capable of running over long distances.

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gravity, hence the possibility of hastening the gallop. In the second case, education assists nature within limits narrower, but still appreciable, to the extent that it teaches the horse to extend himself calmly and to avoid imposing upon himself ill-timed efforts.

Horses of average capability are those whose mechanism can the more easily benefit by those modifications which come from wisely applied training.

Retz, for example, who was best suited at a mile and a quarter, to a mile and a mile and a half, won in 1902 la poule d'Essai at a mile, the Jockey Club Stakes at a mile and a half and ran a magnificent race over the mile and seven furlongs of the Grand Prix de Paris.

But training by modifying the mechanism of the horse gives him sometimes a persistent second nature.

This same Retz, trained over the Grand Prix distance, was unplaced in the Prix du Ranclagh (5½ furlongs), and Prix de la Forêt (7 furlongs).

To those who, in spite of the preceding considerations, are still skeptical, we present the following table which will enable them to understand the important changes brought about in the model of the thoroughbred breed during the last half century.

TABLE OF MEASUREMENTS

	Inclination to the Horizon		Scapulo-humeral Angle	Inclination to the Horizon		Ilio-femoral Angle
	of the Scapulum	of the Humerus		of the Ilium	of the Femur	
Fitz - Gladiator (1850).....	51°	62°	113°	20°	80°	100°
Lemoigne (1877).....	65°	56°	121°	35°	78°	117°
Goubaux and Barrier (1884)	60°	50° to 55°	110° to 115°	30° to 35°	80°	110° to 115°
DeGasté (1903)	61°,8	45°,9	107°,7	23°,5	48°,02	71°,52

This table comprises measurements taken at different times.

The first measurements refer to Fitz-Gladiator, foaled in 1850, died in 1874, a good race horse, but especially illustrious as a sire. He is the father of Gabrielle-d'Estrées and of Mon Etoile, of Compiègne, of Vertugadin and of Orphelin. He claims among his descendants Mortemer, Verneuil, Chamant, Saxifage and Ténébreuse, and a host of other animals remarkable for their conformation, and for their performances and particularly brilliant over long distances.

These measurements were taken by those learned professors at Alfort (the French Military Veterinary College—Translator), Messrs. Goubaux and Barrier (Traité d'Extérieur, 1884).

The second measurements, date from 1877, they are averages figured by M. Lemoigne, professor at the Veterinary School of Milan.

The third measurements are also averages by Messrs. Goubaux and Barrier (Traité d'Extérieur, 1884).

The last are the result of the researches of M. de Gasté in 1903, which appeared in his work, "Le Modèle et les Allures."

A glance easily shows the trend of the changes.

The shoulder rises 10°, the arm increases its slope by 16°; we find variations of 30° in the ilio-femoral angle.

The model of the thoroughbred is not, of course, the exclusive possession of the thoroughbred; it is found in races which the thoroughbred is charged with improving. To see how far the types of to-day are from old-time types, it is sufficient to look at the measurements of the horse of Tarbes and of the Irish horse in the work of M. de Gasté.

	Inclination to the Horizon		Scapulo-humeral Angle	Inclination to the Horizon		Ilio-femoral Angle
	of the Scapulum	of the Humerus		of the Ilium	of the Femur	
Tarbes Horse....	60°,88	45°.7	106°,58	27°,34	45°,88	73°,22
Irish Horse, after de Gasté..	61°,09	48°,2	109°,29	27°,94	45°,81	73°.75

Where are the magnificent hunters, whose impressive lines were traced by Herring in his "Hunting Scenes." Question the old horse copers who frequent English and Irish fairs, and they will reply, "You can't find 'em."

But it is not only a question of esthetics; the model of the present day thoroughbred corresponds to a decidedly inferior type of saddle horse.

We have already seen that the present-day thoroughbred is incapable of long sustained effort in a race on account of the frequency of his contractions which wear

him out. His choppy gait makes him uncomfortable, and, above all, he lacks solidity; he is exposed to frequent stumbles and falls.

One cannot give the name of stumbling to the fact of knocking against a hump in the road or against a rock during the rotation of the leg in suspension; the old-fashioned horse was as capable of this carelessness as the horse of the present day, perhaps even more so.[1]

But this negligence offers no danger because the leg which hits the obstacle folds up and clears it. The true stumble takes place at the moment of grounding; it is dangerous only when the horse has not the time to correct it, that is to say, if the critical moment when equilibrium is broken takes place almost immediately after the grounding of the foot. The latter is almost exactly the case of the horse whose shoulder is vertical, and whose arm is sloping (we have already demonstrated this), of the horse in which the oscillation of the legs on the ground is reduced to its minimum. The old-fashioned horse did not stumble in this way, or, if he did, he recovered himself in time, and it is in vain that we have searched in our memory for a thoroughbred of thirty years ago with broken knees. I wish we could say as much of the horse of to-day.

This lack of steadiness of which the animals themselves are well aware has changed in a very appreciable way the behavior, and even the "morale" of the horse. Formerly one of the favorite manifestations of the thoroughbred, whether from bad temper or from excess of joy, was kicking out behind. To-day horses no longer kick, they no longer have any confidence in their fore hand; besides, perhaps, the action is made harder for them by the new angle of their hip.

[1]The reason for this was the greater length of the arm. The old fashioned type of horse used to drag his foot a little. The present day horses have a higher action, but they are far from being steadier on their feet for that reason.

The riding of a modern horse requires precautions and consideration which were not absolutely indispensable with old-time horses. As he is not very steady in front our new type requires that he be held as little as possible, that he be allowed the free use of his neck for the benefit of his equilibrium; the rider should then use a great deal of leg and very little hand, as all hand action tends to throw the horse to his knees. It was not so formerly and, without wishing to deny the progress of equitation, we may, nevertheless, affirm that, without bothering the old-fashioned horse and without bringing on any other grievous result than to make him pull back at you—one could pull on the reins without fear of endangering the stability of one's mount.

* * *

This insidious evolution of the model has not been accomplished without causing anxiety to a good many minds. Men who, by taste or by profession, study and judge horses were not long in realizing that the precepts of the old masters, the beauties to which they were accustomed were no longer applicable to the animals which they now see.

These men are right. Good horses—for there still are good horses, and we are far from claiming that quality has deteriorated—good horses no longer show the characteristics described by Vallon, Richard du Cantal, de Curnieu. Great performers are no longer remarkable for obliquity of shoulder, verticality of arm, and horizontality of croup; on the contrary, our attention is drawn to peculiarities to which no importance was attached by men of former generations; we mean muscular peculiarities, and there has been invented the new term, "points de force," for designating the muscular relief of the quarters and of the elbow region.

The old masters were all but accused of being in their dotage. And still they also were right: the horse which they described was, indeed, the good horse of their period, the great performer over long distances. They knew, as well as we do now, that a horse must be well muscled, but the horse built on the lines of which they were thinking could not have had the same muscular relief as the chunky animal with short muscles that one generally sees winning races now, and consequently they did not draw the attention of their pupils to this point.

They recommended horizontality of croup, and they very correctly showed that the long horizontal croup was that of the fast horse, of the horse with greater extent of contraction, as opposed to the one with intense contraction. They had not even seen the animal of frequent contraction. We have shown that this latter type with its fore hand excessively lowered as the result of the obliquity of the arm could not exist with a horizontal croup unless the femur was shortened and thus rendered insufficient. To preserve a longer femur, it was necessary to slope it and to keep a favorable incidence of muscle it was necessary to rotate the hip.

The horizontal croup, therefore, became impossible with the new type. From that point it was but an easy step to the inference that the horizontal croup was bad in itself, and capable only of satisfying the misinformed partisans of an arbitrary estheticism. Horizontality of croup has become the bugbear of a goodly number of present-day horsemen.

And still there is no really smooth gait, no truly progressive propulsion, and consequently no easily sustained effort without the long ischio-tibial muscles which are the appurtenances of the horizontal croup, the croup of Monarque, the croup of Fitz-Gladiator, and that of their produce, and all who have ridden the sons of these celebrated

stallions have cherished the memory of the ideal saddle horses they were.[1]

A peculiar fact:—[2]

In spite of the results furnished by the racing, in spite of the indications given by measurements, the most distinguished modern hippologists, Goubaux, Barrier, Jacoulet, Le Hello, as well as their elders, have continued to consider slope of shoulder and horizontality of croup to be characteristics of the fast horse and to quote the classics in support of their opinions. They seem not to have realized the evolution which has changed the race horse into a specially built sprinter, unique in his gait, and unique also in his model.

Into the mass of our present-day thoroughbreds which have suffered the change which we are studying, there has slipped in each generation and as the result of a well-known phenomenon of atavism, a few rare individuals whose model recalls that of an ancestor. There are but few chances that such a restricted number should contain an animal of extraordinary powers; still there are to be found among them a few who are not entirely lacking in quality. Their mediocrity denies them success in classical races of short and medium distances, but their conformation, which makes them at home over long distances, enables them sometimes to win in races like the Prix Rainbow and the Prix Gladiateur.

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[1]The upright croup is really advantageous only for sprinters, as we have just shown, and for the high jump, especially for the standing jump. The angle of incidence of the ischio-tibials is very favorable from the beginning of the movement, and the quickness of their contraction helps to make a very brilliant jump.

[2]Note on the other hand, that in his "Principales donnés qui servent de base à la connaissance du cheval," M. Le Hello says on page 110, note 1:

"The direction of the scapular radius has not such a preponderating influence upon speed as has generally been thought. The direct proof of this is given by Bruce, Michigan, Harley, etc., who were performers of the highest class, although in their shoulders they were most ordinary, not to say lacking." And on page 121:

"Although the shoulders are more horizontal in the runners, they have a wider scapulo-humeral angle, as a result of the relative verticality of the bone of the arm. It must be admitted, however, that this characteristic has much more influence upon smoothness of gait than upon speed."

When such an event happens the sporting press explains it in one word, "Aptitude," and the word is right; but in certain minds it would seem that aptitude to run a distance is incompatible with quality, and that is false. A mediocre animal with aptitude, that is to say, with the proper model and the proper mechanism will, over long distances, beat ill-constructed animals of high quality; this does not prevent high quality's existing side by side with aptitude, and that was the general rule twenty years ago. It is enough to look over the list of winners of the Prix Gladiateur (3 miles and 7 furlongs) to find the names of Surprise, Mon-Etoile, Souvenir, Noélie, Gladiateur, Vertugadin, Trocadéro, Don-Carlos, Dutch-Skater, Nougat, Mondaine, Verneuil, Clémentine, Mademoiselle-de-Senlis, Upas, Ténébreuse, all of them remarkable animals. Since 1890, the high quality of the winners has not been maintained so continuously. It is certain that Carmaux, Mirabeau, Patriarche, Mademoiselle-de-Longchamps, Rabat-Joie, and even Aquarium owe their success to their mechanism rather than to their quality; but Omnium II., Maximum, Clyde et Punta-Gorda were animals of a high order.

The Prix Gladiateur had, therefore, the greatest significance at the time when a great majority of horses were built as stayers, and it crowned the career of those most remarkable for their quality. To-day it has lost its meaning, because for a generation the best race horses have been so constructed that it is impossible for them at a long distance to beat a mediocre animal which has in his favor only a good mechanism.

Is it not natural that we should deplore such a result? The admirable horse which we had thirty years ago, so well made for improving our breeds of horse for military service—since he had all the good points which the most exacting rider could demand—so full of real qual-

ity—since he could compete at equal weights with the English horse, and even beat him on his own ground (witness the victories of Monarque, Fille-de-l'Air, Gladiateur, Jongleur, Chamant, Verneuil, Rayon-d'Or, etc.) —this admirable horse is by recent conditions eliminated from the turf, eliminated from the studs and destined to disappear if he has not already done so.

We have quoted " Sincere's " cry of warning; others have been uttered by persons eminently qualified to do it. They do not seem to have been heard. Perhaps there was too much insistence on a point easily disputed; we mean the lack of substance for which our present-day horse has been criticized.

There always have been big horses and little horses, and it is easy to mention such prominent animals as d'Ermak, Vinicius, Val-d'-Or, Maintenon, Sea-Sick, and so many others who are not a bit less developed than the most remarkable models of former times, for instance, Chamant, Verneuil, Saxifage, Rayon-d'-Or; but the essential difference is that the little horses of former times were rangy in their lines, while the biggest and heaviest horses of to-day lack length; they appear to be small, the standard and the scales are needed to realize their height and weight.

It is right that the stayer should have a strong skeleton, but he will never be a beefy animal, and the enormous muscular relief which is so much admired in our present-day horse gives but a poor account of itself over a distance.

* * *

It is now time to sum up this already too lengthy study. We do not claim to have discovered that the model of thoroughbred has essentially changed, but we believe that we have fixed upon the direction of these changes; we believe that we have proved that these changes were fatal,

in view of the kind of galloping stride required by short distance tests; we believe ourselves to have proved that with equal quality the horse adapted to the present tests must necessarily triumph over the horse whose model is of the old type, and that consequently there is no longer room for the latter; eliminative selection has evicted him, little by little from the turf and from the stud, and will soon make him disappear.

We believe that we have demonstrated that our fathers knew how to judge a horse; that the true precepts of their time would still be the precepts of our time, if we had had the sagacity to look where we were going and where we wished to go. What kind of horse does racing claim to give us? Evidently a horse to improve our service breeds; the service horses should inherit from him his general shape more or less amplified and a part of his quality. Would it not have been natural to decide upon the desired aptitude and model, and then to seek after the kind of tests, which by selection should produce quality in this model? For quality can exist with any kind of model, while aptitude is essentially dependent upon the model.

We were shown the road, and we had no innovations to make. We have preferred to follow the English who, in spite of their well-known good sense in matters of breeding and sport, have committed the grievous error of confusing stamina and speed, when in reality these are both distinct manifestations of quality and things have come to such a pass that it is impossible, either in France or in England to find a suitable stallion to breed with cold-blooded mares.

The situation is serious, and all the more serious because the crisis, which has so seriously crippled the production of the carriage horse, imposes upon the horse industry the necessity of falling back upon the produc-

tion of the saddle horse, and consequently of employing more than ever the thoroughbred factor.

Theoretically, the remedy is simple. "Sincere," in his "Etude hippique," clearly indicated it, rearrangement of programmes, increasing the number of distance races, giving them the richest prizes, thus making of them the criterion of quality; reserving for intermediate distances a modest budget and a consolation budget for short distances; diminishing the number of two-year-old races and correspondingly increasing the number of races for older horses.

But, in practice, what difficulties there would be found in the application of this remedy! What a number of carefully built-up establishments would become useless!

If ever the experiment were tried, how much time it would take us to go backwards over the road already so painfully traveled.

For ten years, at least, it would be necessary to resign ourselves to the painful spectacle of seeing our long distance races run for by animals especially adapted to sprint races. It would take, perhaps, twenty years more to effect the change, which would make the horses equal to their tasks, that is to say, to bring us back to the starting point.

Is it too much to assume that we would not be in this deplorable situation if the analysis of the galloping stride had been thought of in time.

Tarbes, March 27, 1909.

II.

The Croup and the Hind Legs in the Gallop.

As in the study of the forehand, it is to the chronophotographic plates of Marey and Pagès that we shall turn for analysing the movements of the hind legs, remaining faithful to our method, which consists in deducing from dynamic knowledge of the horse, which is given

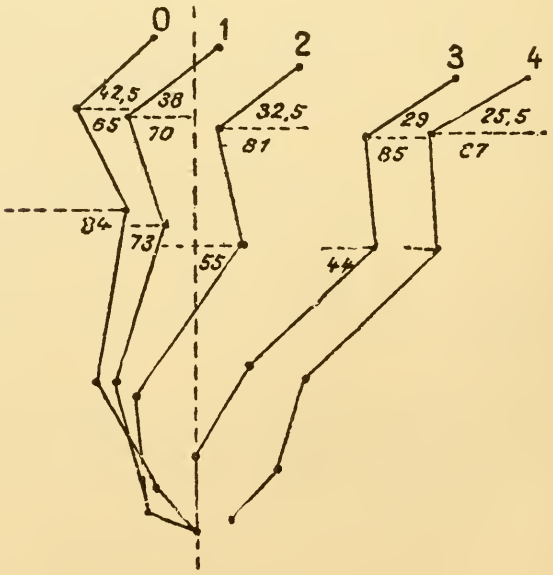

Fig. 5.

us by instantaneous photography alone, a static knowledge of him which can be seized by the eye in its entirety and in detail.

A. Period of Support of the Hind Legs at the Gallop.

Figure 5 represents a hind leg at the gallop, from the time it arrives on the ground until it leaves the ground, that is to say, during the whole period of propulsive effort.

The study of the angles with the horizon of the various radii and of the variations of the angles at the joints during this period show:

a. The inclination of the ilium to the horizontal has the following values:

Position	0	42°.5
"	1	38°
"	2	32°.5
"	3	29°.
"	4	25°.5

b. The inclination of the femur to the horizontal is as follows:

Position	0	65°
"	1	70°
"	2	81°
"	3	85°
"	4	87°

Note that at position 4 the leg has just left the ground, the femur is beginning to close again towards horizontality, and there has been very probably between position 3 and position 4 an intermediate position which has not been seized by the camera, and where the inclination of the femur to the horizontal was more than 87°. We, therefore, shall not consider position 4 in our argument.

c. Variations of the coxo-femoral angle:

Position	0	107°.5
"	1	108°
"	2	113°.5

d. Inclination of the tibia to the horizon:

Position	0	84°
"	1	73°
"	2	55°
"	3	44°

e. Variations of the femoro-tibial angle:

Position	0	149°
"	1	143°
"	2	136°
"	3	129°

f. Inclination of the metatarsus to the horizontal:

Position	0	63°
"	1	79°
"	2	86°
"	3	121°

g. Variations of the tibio-metatarsal angle:

Position	0	147°
"	1	151°
"	2	141°
"	3	165°

h. Inclination of the phalangian lever to the horizontal:

Position	0	49°
"	1 and 2	27°
"	3	90°

i. Variations of the metatarsal-phalanges angle:

Position	0	166°
"	1 and 2	130°
"	3	150°

The examination of these tables gives us the following facts:

1. The hip moves toward horizontality during the whole period of support; it changes by almost 20°, but these variations of slope do not come from a motion peculiar to the hip itself. Firmly fixed to the sacral vertebræ, the hip is susceptible of no rotation and its changes of slope are only the measure of the play of the lumbar arch, which, set like a bow during the period of suspension, springs and straightens out during the period of support. This very important action of the lumber arch is productive of impulse and effectively helps the lightness and power of the gallop. But it is well known that the opening of an angle means the production of impulsive effort. In the species under consideration, it is a question of the imaginary angle A B C

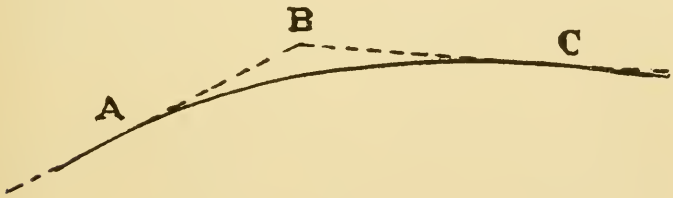

FIG. 6.

(Fig. 6) formed by the intersection of the two tangents A B and B C to the double curvature of the loins. When the angle A B C opens, the line A B (which corresponds practically with the direction of the ilium) moves toward horizontality. It is this which explains why the movement of the hip toward horizontality has no shock absorbing effect, but it is the result of the production of force. From this remark can be drawn the immediate conclusion that one should not seek too short a loin in a powerful animal:

2. The femur rises toward verticality with a constant movement and the coxo-femoral angle opens, hence propulsion.

3. The tibia closes toward horizontality and its movement has a width of 40°. The femoro-tibial angle closes about 20°. It therefore does not assist in propulsion. Its role is to be a shock absorber, at least, during positions 0, 1 and 2.

The stifle is lowered during the whole period (even when the pastern straightens up). It is this peculiarity which permits the femur to straighten up without having to raise the weight of a part of the hind quarter. The coxo-femoral joint slides, so to speak, softly upon an inclined plane. The very weight of the hind quarter assists the production of this motion.

4. The metatarsus moves toward verticality.

The tibio-metatarsal angle begins by opening slightly to the extent of 4° between positions 0 and 1, then it closes by 10° between positions 1 and 2, and finally opens quickly by 24° at position 3.

These variations must be interpreted.

In spite of the opening of the tibio-metatarsal angle between position 0 and position 1, contrary to what one may, and have, supposed, there is no propulsion.

The metatarsus straightens up more quickly (16°), then the tibia bends, and this rapidity is because the lower extremity of the metatarsus (the fetlock joint), in consequence of the bending of the pastern, is carried behind the position which it occupied at position 0. Hence, opening of the tibio-metatarsal angle, but there is no question of impulse since the phalangian lever which acts as a base for the metatarsus is in the act of bending, and could not give them a sufficiently solid support to make an effort useful in propulsion.

The above explanation becomes evident if one considers what takes place between position 1 and position 2 when the tibio-metatarsal angle closes by 10°. It is very certain that it plays, up to that time, at the level of the

hock, the same shock absorbing role as the femoro-tibial angle at the other end of the tibia plays at the level of the stifle.

But between positions 2 and 3 (and probably nearer to position 3 when the phalanges becomes vertical), the tibio-metatarsal angle, opens quickly by 24°, and energetic propulsion is produced.

Thus the tibio-metatarsal angle changes from the shock absorbing role which it has during the first part of the period of support, to the role of propulsion to the second part.

5. The phalangian lever begins by moving toward horizontality during the first part of the period of support and rises toward verticality during the second part; the metatarso-phalangian angle follows the same variations, beginning by closing and then opening, assisting first shock absorption, and then propulsion.

The radii which become erect, the femur during the whole period of support, the metatarsus and the phalangian lever during the second part of this period, are the only ones which contribute to the total stretching of the leg, and consequently are the only ones which participate in propulsion. It will seem advantageous for propulsion, therefore, to lengthen these radii.

So far as the femur is concerned, this is doubtless so. This radius acts as a lever for the extrinsic muscles (the rump muscles, the ischio-femorals and the ischio-tibials), which produce propulsion from the very beginning of the period of support; its great length which implies great length of the ischio-femorals and ischio-tibials is eminently favorable to power of propulsion.

The case of the metatarsus is not the same: the twin muscles which act at the top of the hock make of this radius an inter-resisting lever in which the difference between the lever arm of force and that of resistance (length of the cancaneum) remains constant when the

length of the canon bone is changed. The lengthening of this radius is, therefore, of no particular benefit to strength. But we will see later that the length of the canon bone has an appreciable importance in the length of the stride (formation of the third step of the gallop); the canon bone of the hind leg of the sprinter must, therefore, not be too short.

Excessive lengthening of the phalangian lever would be ruinous to the tendons. Too great shortness, must however, not be sought after in this region. See on this subject the note on page 17, which explains the close relation existing between the rotation of the phalanges and that of the legs.

We are then permitted to conclude that in the interest of propulsion the femur should be long compared with the tibia, that the canon bone must not be too short. This double condition imposes upon the tibia a relatively reduced length. The twin muscles which stretch over the rear part of the tibia will then be relatively short, which is not a disadvantage if they are strong. Inserted in the crest of the calcaneum these muscles act very quickly upon a short lever, whose motion is almost immediately stopped. They need, therefore, strength, not length.

Before closing this analysis of propulsion, it must be noted that the movement begins at the same time as the straightening of the lumbar arch by the extrinsic muscles which change the coxo-femoral angle.

This action is progressive; the coxo-femoral angle opens by a ½° from position 0 to position 1, then quickly by 4½° from position 1 to position 2, and continues to open slowly by ½° from position 2 to position 3. It is precisely at this moment that the tibio-metatarsal and the metatarso-phalangian angles assume their propulsive role by opening the former by 24°, and the latter by 63°.

B. Period of Suspension of the Hind Legs in the Gallop.

A similar analysis for the period of suspension of the hind legs at the gallop shows the following (Fig. 7):

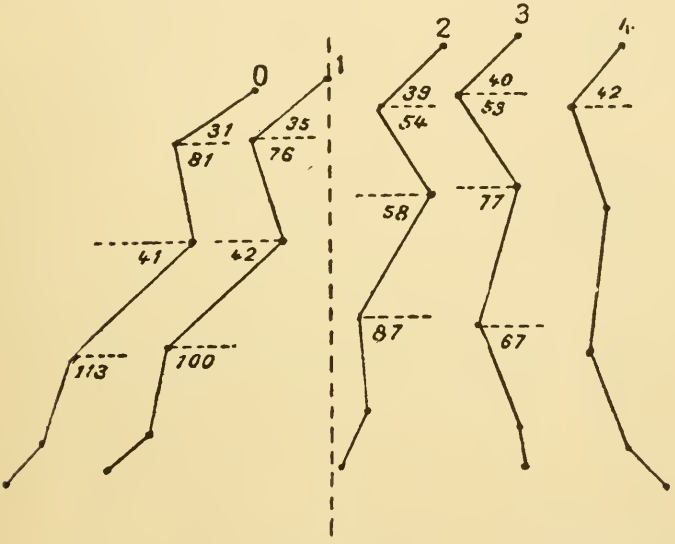

FIG. 7

a. Slope of the ilium to the horizontal:

Position	0	31°
"	1	35°
"	2	39°
"	3	40°
"	4	42°

(At position 4 the foot is grounded.)

b. Slope of the femur to the horizontal:

Position	0	81°
"	1	76°
"	2	54°
"	3	53°

c. Variations of the coxo-femoral angle:

Position 0	112°
" 1	111°
" 2 and 3	93°

d. Slope of the tibia to the horizontal:

Position 0	41°
" 1	42°
" 2	58°
" 3	77°

e. Variations of the femoro-tibial angle:

Position 0	122°
" 1	118°
" 2	112°
" 3	130°

f. Slope of the metatarsus to the horizontal:

Position 0	113°
" 1	100°
" 2	87°
" 3	67°

g. Variations of the tibio-metatarsal angle:

Position 0	154°
" 1	143°
" 2 and 3	144°

So, during the period of suspension the hip bone becomes more upright; but as we pointed out above, these variations of slope are not the result of a movement proper to the hip bone. They come from the lumbar arch, which after bending straightens out again when the period of support begins.

The femur becomes more sloping and the coxo-femoral angle closes.

The tibia straightens up, and the femoro-tibia angle opens at the end of the period.

The metatarsus becomes more nearly horizontal, and the tibio-metatarsal angle closes at the end.

The muscles which put these different levers into motion are the " fascia lata " (the flexor of the femur, which goes from the ilium to the stifle), the " triceps crural," the tibial extensor situated on the forward face of the femur, and finally the flexor of the metatarsus (situated on the lower part of the femur and the forward part of the tibia).

These muscles have to overcome only the resistance represented by the weight of the portion of the leg which they have to move; they therefore do not need much strength and could get along with fairly short lever arms. But there is an advantage in having the widest possible oscillation, so that the hind foot may resume contact with the ground as far under the mass as possible. To this end the thigh must flex as much as possible, therefore the " femoral flexor " must be as long as possible. It is also necessary that the leg should become as upright as possible, and to that end the tibial-extensor must be as long as possible. This double condition can be obtained only with great length of femur. Besides, great length of this lever becomes very advantageous when the horse is galloping on heavy ground, for it is the femoral-flexor whose duty it is to overcome the resistance of the earth and pull the feet out of the mud.

It is easy to see from the sketch (Fig. 8) that a change in the skeleton by which the femur is lengthened relatively to the tibia, brings the hind foot further forward under the mass, and later to the ground.

This is easily seen by examination of the leg A B C D and of the leg (with the lengthened femur and shortened tibia) A B′ C′ D′.

This same sketch shows that the opposite result would be produced if the tibia were lengthened at the expense

of the femur, as is shown by the leg A B′ C′ D′, and the leg with the shortened femur and lengthened tibia A B C D.

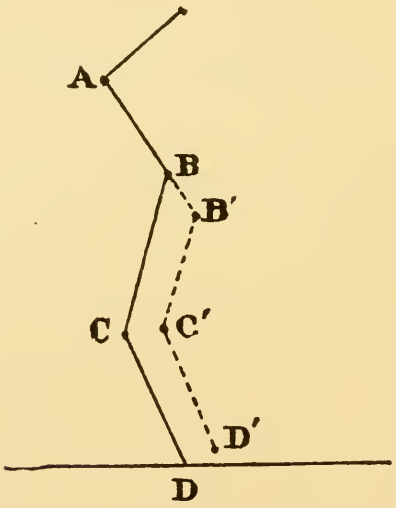

Fig. 8.

We have assumed in this example, that the lengthening of the femur did not change the width of oscillation of this radius. In reality this is not so, and the lengthening of the femur, which implies the lengthening of the "flex-or-femoris," would bring on a greater flexing of this lever, which would accentuate still more the result which we have just pointed out.

It is then seen that during the period of suspension (which is a preparation of the hind legs for grounding), as well as during the period of support or propulsion, great length of femur is particularly advantageous.

C. The Role of the Hind Legs During the Formation of the Diagonal Base (third step of the racing gallop).

To be complete, our study must contain an examination of the role which, in addition to that of propulsion, the hind legs play in the formation of the diagonal base.

The extent of this diagonal base, which, for speed, should be as long as possible, is measured by adding the

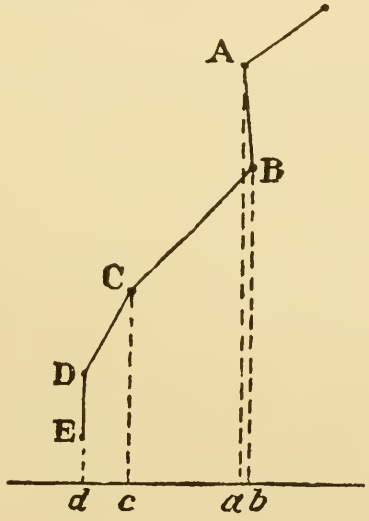

FIG. 9.

Figure 9 is the reproduction of figure 5 (position 3).

horizontal projections, of the fore legs, of the body, and of the hind legs.

It has been seen in the first part of this work that the more correctly the shoulder and arm are placed, the longer will be the projection of the fore legs; the projection

The projection of the phalanges is nothing, and that of the femur negative, but it must be noted that the Marey and Pagès plates are not taken from a horse at racing speed. At this gait these projections, however small they may be, would certainly have a positive value.

of the body is constant for animals of the same length; there remains the projection of the hind legs. The latter is evidently composed of the sum of the projections of the femur, of the tibia, of the metatarsus, and of the phalanges. Now a glance at Fig. 9 will show that the projection of the femur is almost nothing, as is also that of the phalanges, and that the projection of the leg is determined by that of the metatarsus, and especially by that of the tibia.

Length of tibia, and consequently relative shortness of femur will then be favorable to length of the third step of the gallop.

CONCLUSIONS.

The results of this analysis give us a full knowledge of the construction of the sprinter of whom so far we had only studied the fore hand.

The sprinter will have a relatively short femur and a relatively long tibia.

A short femur is unfavorable to strength, and requires for putting it into action a more considerable expenditure of force, whence fatigue and limitation of the length of the effort; but the muscles which determine this movement, fastened as they are to a low and relatively short ischium, give a more sudden propulsive effort and hasten the oscillation of the leg in support.

The diagonal base, unfavorably affected by bad construction of the radii of the fore legs, finds a certain compensation in the length of the tibia. Finally, during the rotation of the leg in suspension, the flexors of the thigh and the extensors of the leg, very rapid by reason of their shortness, produce quickly the extension of the tibia, whose length permits the foot to take earlier contact with the ground, which fact shortens the period of suspension at the gallop.

In addition, it is well understood that, whatever the length of the tibia, it must be strongly muscled; its role is to stiffen the hind leg during propulsion. It acts as a truss, on the one hand, for the femur, which straightens up at its upper end, and, on the other hand, for the metatarsus which straightens up at its lower end.

Is it necessary to say, after what has been said above and in the first part of this work, that the femur of the stayer should be long and his tibia short?

This conformation will give him power of propulsion, or more correctly, the faculty of pushing himself along with a minimum of effort. It will increase the time of suspension (condition indispensable to staying power); it will permit him more easily to pull himself out of heavy ground.

This is (we are convinced of it, and measurements on this subject would be interesting) the secret of the superiority of certain horses and certain families which are said to like the mud. Except individuals whose legs are in such a sad condition, that galloping on hard ground is painful to them, there are no horses that like the mud, any more than there are swimmers who like to swim up stream; but there are animals built in such a way that they can make and sustain an effort of which others are incapable.

Finally in spite of the relative shortness of his tibia, the stayer is assured of the correct formation of his diagonal base by a correct arrangement of his anterior radii.

The croup of the stayer will be long and almost horizontal. At equal lengths the horizontal croup has muscles longer, and consequently susceptible of more extensive contraction; his femur is nearer to the vertical. He has, therefore, a field of oscillation less limited in each direction; it can be wider without being interfered with by the abdominal region of the horse.

Some hippologists have said that the coxo-femoral angle should be as small as possible, so as to open wider at the moment of propulsion. This is not absolutely true; the truth is that the coxo-femoral angle should have all freedom to close, in order to have the same freedom in the opposite direction. A croup close to the horizontal with a thigh close to vertical will satisfy this double condition in the best way.

In absence of chronophotographic plates of the horse at racing speed, it is very difficult to determine exactly what the direction of the femur should be at the stand still. We must, therefore, be satisfied with measurements; those of MM. Goubaux and Barrier are very valuable because they were made before 1884, consequently more than thirty years ago, at a time when the best race horses were stayers. These authors found that the croup of the race horse of that time was close to horizontal (about 30°), and that the slope of the femur was about 80°, a direction almost vertical.

The femur approaching horizontality is generally short, otherwise the play of the stifle would be interfered with by the flank and the plumb of the hind quarter would be defective. Still the femur should not be vertical. It is important that all the muscles of the hind quarter should assist in absorbing the shock of gravity at the level of each joint. If the femur were vertical the rump muscles and the ischio-tibials would have nothing to do in maintaining the opening of the coxo-femoral angle, the weight would be integrally transmitted to the stifle joint, and would throw increased work upon the tibial-extensor, in opposing the closing of the angle at the stifle. It can be added that a vertical femur would make a femoral-flexor longer than the ischio-tibial muscles which would be unreasonable.

It seems, then, the femur of the stayer should be inclined about 80° from the horizontal (that is the slope found in Fitz-Gladiator); on the other hand, the importance of the length of this radius need not be further argued; the result is that if one considers the necessity of having normal plumb (the vertical dropped from the point of the rump should touch the point of the hock and be tangent to the flexor tendons); if the height of the hock above the ground is also normal, the length and direction of the tibia are fixed within narrow limits which depend especially upon the length and direction of the ischium.

We have just shown the best form of croup for a distance horse; what changes could we make in it without thereby making it defective? After the preceding explanation it is certain that if the direction of the hip were maintained, and at the same time the femur shortened, the stayer is no longer a possibility; if, on the contrary, the sloping of the croup left the femur its original length (in this case the coxo-femoral angle must open) we would, however, still have a distance horse, especially if the fore hand is well modeled. That was the conformation of two remarkable mares, Clyde and Basse-Pointe, both of which won the Prix Gladiateur.

Perfection of the hind quarter can also make up for a small defect in the forward radii; that was the case of Jerry M, winner of the Liverpool Grand National and of the "Grand Steeple Chase d'Auteuil," but, in our opinion, nothing can compensate the stayer for a too short femur.

III.

Nature is too strictly reasonable to maintain, that when it creates a form, this form can be used indefinitely for all kinds of service. We have already shown that the horizontal croup was not that of the sprinter. We will now examine the criticisms to which the croup is generally subjected, and the extent to which these criticisms are justified.

A. Influence of the Direction of the Croup upon the Manner in which the Horse Supports Weight.

The horizontal croup has frequently been reproached with being less well constructed than the sloping croup for bearing weight. This reproach is well founded.

It appeared interesting to us to determine, at least in an approximate way, the measure of this inferiority.

Take the sketch herewith (Fig. 10).

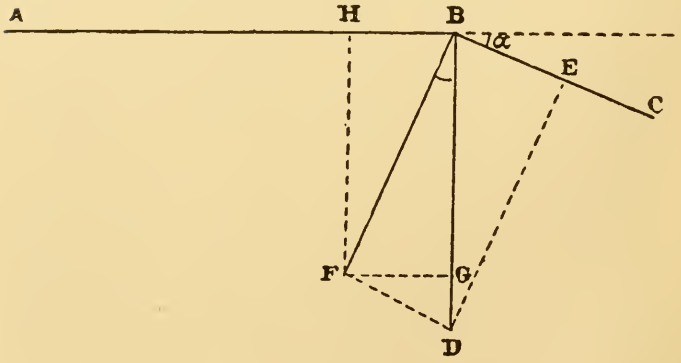

Fig. 10.

The line A B represents the spinal column, B C is the direction of the ilium making with the horizontal an angle α.

The vertical B D represents that part of the weight of the rider supported by the loin.

The force B D can be decomposed into two others, B E in the direction of the ilium, which will be absorbed by the muscles of the hind quarter, and the other B F, perpendicular to the ilium.

The force B F which acts obliquely upon the loin is also decomposed into two others, one B H, horizontal, is taken up by the mass of the body; the other, vertical, B G, represents exactly the weight which is felt upon the lumbar region.

Now we have $BG = BF \cos FBG$.
And as the angle $BFG = \alpha$
We have $BG = BF \cos \alpha$,
But, $BF = BD \cos BFG = BD \cos \alpha$.
Hence, $BG = BD \cos^2 \alpha$.

From recent experiments of M. Barrier, B D is equal to a quarter of the rider's weight hence $BG = \frac{W}{4} \cos^2 \alpha$. The weight on the loin is then proportional to the square of the cosine of the angle made by the croup with the horizontal; and since the cosine decreases, as the angle increases, it will be seen that the weight supported by the loin will be smaller as the slope of the croup increases.

To fix the idea more clearly, let us consider two croups inclined, one at 20° (horizontal croup) and the other at 40° (very sloping croup) and let us suppose the weight of the rider to be 100 kilos.

The Cos of $20° = 0.9425$.
$\cos^2 20° = 0.8883$.
The Cos of $40° = 0.7675$.
$\cos^2 40° = 0.589$.

In the case of the horizontal croup, we will have
$BG = 25 \cos^2 20° = 22.2075$ kilos.

And in the case of the sloping croup, we have
$BG = 25 \cos^2 40° = 14.725$ kilos.

Or a difference of the 7 kgr. 4825 between these two values.

So the horse with the horizontal croup will bear upon his loin nearly 7½ kilos more than the horse with the sloping croup.

In other words it would be necessary to reduce by four times 7½ or 30 kilos, the weight of the rider of the horse with the horizontal croup (which would bring this weight to 70 kilos), in order to equalize the weight supported at the loin by both horses.

It is important to note that these two figures have their strict value only when the horses are considered to be standing still; this value lessens as soon as they move and consequently change their angle, and at the gallop, for example (when the lumbar arch is working well), the weight is distributed in almost the same way whatever the slope of the croup. It is besides a fact of common observation that the horse with a horizontal croup, at first a little surprised when heavy weight is put upon him, hastens to change the slope of his radii, and if he has the least energy takes up the gallop of his own accord.

The light rider should therefore not hesitate to choose a horse with a horizontal croup which will carry him faster, more comfortably and more powerfully than any other. The heavy rider should take a mount with a more or less sloping croup. The croup can never be too much inclined, nor the loin too short for a work horse which is to bear the jerking weight of the shafts of a heavy two-wheeled cart.

But this study was not for the purpose of giving advice to riders in search of a mount; it is simply trying to point out the best methods of selection of progenitors destined to improve the breeds of saddle horses, and one objection is immediately presented to the mind—is it not to be feared lest long distance racing, which favors

the selection of rangy animals with horizontal croups, bring to the stud stallions incapable of producing horses with more or less sloping croups, whose merits as weight carriers must be admitted?

To this objection we reply positively no. If there are many thoroughbred horses whose croups are more or less sloping, it is none the less true that the horizontal croup is the exclusive possession of the noble breeds; so, in our opinion, there is no reason to fear that the thoroughbred stallion, with grand lines, used for crossing, will not find among the more or less common mares brought to him the necessary corrections for horizontality in the hindquarters.

B. Influence of Horizontality of the Croup in Jumping.

It is generally admitted that obliquity of croup is advantageous for jumping. And, in fact, we find many good jumpers with a very sloping croup.

Still it would be wrong, from this special point of view, to condemn the horizontal croup.

It must not be forgotten that the jump comprises a period of preparation and a period of execution.

In the period of preparation the horse imitates the motion of rearing, by making an effort with his forelegs to raise the forehand and by bringing the hindquarters strongly into play.

Let us consider only the role of the hindlegs.

It is evident that the horse with the sloping croup has, from his very conformation, a minimum effort to make in the period of preparation, and the advantage which this disposition of the radii gives him is easily understood when it is a question of the jump from a standstill, from a walk or from a very slow gait. The fact is that the ischio-tibial muscles have, as a result of the lowering of the ischium, a particularly advantageous attachment, and these are the muscles of the hind-

quarter, which contribute the most to the execution of rearing.

But if we consider the horse approaching the obstacle at rapid pace, conditions are completely changed. We have seen how at the gallop, from the first moment of support, the horse with the horizontal croup has his hip inclined in the best way for efficient action of the ischio-tibials, and how, on the other hand, his ischio-tibials, which are longer than those of the horse with the sloping croup, will have more scope of action.

The second period of the jump or the period of execution is characterized by the simultaneous straightening of all the radii of the hindquarter and the length of the femoral lever give advantage to the horse with the horizontal croup.

This horse, therefore, requires impetus in his jump; but in these conditions, and if, besides, he adds to the conformation of his skeleton a sufficient muscular power, he will be a much more brilliant jumper than the horse with the oblique croup.

Who has not noticed the marked inferiority of the latter in the wide jump?

Besides, the exceptionally good jumpers—Conspirateur, Jubilee, Abricot, All-Fours, Double-R, Pouf—are not noticeable for the slope of their croup. Quite the contrary; and one of the most celebrated examples of all is still to be mentioned, namely, Jerry-M, the winner of the " Grand Steeple Chase d'Auteuil " in 1910.

C. Influence of the Shape of the Hindquarter upon the Management of the Horse.

Analysis of the play of the hindlegs brings to light certain facts and explains the truth of certain observations, which in the eyes of their authors seemed to have only an empirical value.

The horse with a long and consequently an almost

vertical femur, with a relatively short, and consequently a more or less upright tibia, will by the very power of his principal propulsive lever be a hard puller if he is spirited in character and, if on the other hand, the correct placing of his forward radii causes him no anxiety upon the equilibrium of his forehand, and if it permits him strongly to attack the wrists of his rider.

"Pull on him as if you were trying to pull a tree down," Henry Jennings used to say to his exercise boys.

And, in fact, the horses of that period, built for stayers, were very much harder pullers than those of the present time, be this said without in the least approving of equestrian advice given by the old trainer.

The horse with a relatively short, sloping femur (if fastened to a sloping croup), with a relatively long and consequently oblique tibia, has not a lever of the same power for struggling against the hand of his rider, and consequently he will pull less.

These observations had not escaped Lord Apperley (Nimrod), the author of highly valued studies on the hunter, of which M. Ollivier, Inspector-General of Studs, has given us interesting extracts in his "Notes sur le cheval de selle." Unfortunately a certain amount of attention is necessary for the understanding of the text, as Nimrod is constantly confusing the terms thigh and leg.

"A horse with short, upright and weak thighs," said Nimrod, "or simply with short and upright thighs, cannot be a good hunter. He can never be balanced in his gallop, nor can he be assembled in front of the jump, and he is almost certainly a hard puller. Horses with hind-legs too straight never have a good mouth."

What proves that everything that Nimrod says above is applicable to the leg and not to the thigh is the fact that he immediately adds: "Consequently a long and muscular thigh, with a clear cut and well-placed

hock, is one of the most important points in the hunter."

The hock is at the end of the leg and not of the thigh, and it is not understood how Nimrod in the same argument brings in the thigh and the hock without mentioning the leg which connects them. It is then necessary in the above quotation to substitute "leg" for "thigh," and that being done there is nothing left but to approve what Nimrod says. He desired for comfortable management a horse with a short thigh and with a long well-sloping leg. It is not the best horse that he describes; it is the most comfortable horse. Besides he says further that "the hunter should have in his levers the correct proportions necessary for producing full liberty of action, but he should not have a too long stride."

The same confusion exists in the terms, without any doubt as to the thought of the author, when he says in this summing up:

"The haunch will be very sloping and implies a corresponding slope in the bone of the thigh (correct term), a conformation which is particularly characteristic of the horse of good birth. . . . The thighs must be well muscled and long (here he means legs), sloping rather inward than outward, with clean large hocks, whose points should appear to be a little behind the body, which fact will bring the lower portion of his hind-legs under him."

From the practical point of view, Nimrod is perhaps right, but he sacrifices to convenience of management both correctness of plumb and a good part of the power of the mechanism.

That is also the opinion of Major-General Hill, quoted and translated by M. Ollivier. General Hill does not confuse the femur and the tibia. He demands first of all "a long femur, ending in a low, bony, muscular, well-developed femoro-tibial joint . . . the stifle cannot be too low." Further on he adds, "A straight leg

approaching the vertical"; he does not speak of the length of this region, but it is evident that since he desires the femur as long as possible, he accords to the tibia only relative length.

The two English authors could not have uttered two opinions more contrary, and I fear that M. Ollivier leaves his readers in a state of perplexity when he adopts without comment an intermediate solution.

The Germans seem to have made up their minds more definitely. One of our most brilliant cavalry Generals, on his return from a recent trip from Germany, told us enthusiastically about the transformation of the German horses in the last twenty years; perfect homogeneity in the cavalry type, no more runaway horses, no long-shanked beasts, animals wonderfully made in front, but a little short and thin behind. The Germans fear powerful croups, which incite the horse to pull. Their horses are extremely easy to manage, even with one hand, and the General saw and admired military manoeuvres of absolute precision. The fact is that this may be admirable from a certain point of view.

These diverse opinions show clearly, at all events, the differences which exist in the ease of management, according to whether the horse has a long or short femur.

IV

The Grand Steeple-Chase d'Auteuil was won in 1910 in a most brilliant way by an English horse named Jerry-M.

Whatever his admirers may say, after his victory, Jerry-M is not an irreproachable model. He does not, however, justify the opinion expressed by a well-known Norman: "What could we not say of him if he were a trotter?"

By his model and by his action, Jerry-M is none the less a very interesting animal to study and one which corroborates in more ways than one the theories formed from the foregoing analysis.

Jerry-M is a very tall horse (perhaps 16.2½ hands high), very rangy, having an exceptionally good frame and muscular development. His neck is a little U-shaped, the shoulder is long, but, like the arm, it has poor direction; the withers are well placed and well prolonged toward the rear; his loin is long and his chest deep. The hindquarter is admirable; in width, length and direction his croup is above criticism; his femur is very long, his stifle is low, his legs very much muscled; his hocks are in the right place; they are perfectly clean and have a great deal of substance.

Jerry-M gallops with a remarkably easy and extended stride, but he carries his head a little low. Good strong arms seem needed to steady him when he wants to run; he is indeed ridden by a strong man after the old English method. It would, perhaps, be hard to ride him otherwise, especially at his jumps. Jerry-M is an exceptional jumper. He proved it in 1912 by winning the Liverpool Grand National under the enormous weight of 175 pounds. At Auteuil the power with which he cleared the water jump in front of the grandstand was truly impressive.

The magnificent action of this steeplechaser is evidently due to the perfection of his hindquarter, to the length of his femur, which allows him to resume contact with the ground further under the center of gravity, to the power of the muscles which move this lever, to the strength of his leg which gives remarkable firmness to his gallop, to the soundness of his hocks; but all these qualities would not be sufficient to compensate for the weak point resulting from the bad direction of his shoulder, were it not for the absolutely exceptional play of his loin which, according to accepted rules, is a little too long and which would be weak in a horse with a less exceptional femur and muscles. According to us it is this play of the lumbar arch, whose importance we pointed out in the first pages of this study, which is one of the principal factors in the gallop of Jerry-M.

Would the winner of this big steeplechase be a hunter out of the ordinary in a rolling country? It is doubtful. The direction of his shoulders would certainly make him a horse hard to use at a fast pace down hill, and when, after a hard day the remarkable play of his lumbar arch became paralyzed or even restricted by fatigue, he would be in an unfavorable condition of equilibrium.

With a shorter loin and a more sloping croup, Jerry-M could carry a house, but then it is very probable that he would no longer have the same facility of jumping and galloping.

Of quite a different model, but none the less worthy of attention, is the celebrated mare Basse-Pointe, of whom the " Sport Universel Illustré," in its last number of October, 1911, gives us a very fine photograph.

What strikes us at first in Basse-Pointe is the perfect direction of her shoulder and arm, the width of her chest, the line of her withers and back. Her croup is strongly sloping and not that of a stayer; but it is to be noticed that the coxo-femoral angle is very open, that the femur

is remarkably long, even exceptionally so in relation to the tibia. The stifle is very low and detached from the body somewhat, as in the greyhound.

We have already had occasion to note that this was Clyde's croup conformation; we might add that it was also that of her illustrious ancestress Plaisanterie.

To avoid repetition we will not insist upon the advantages which this conformation gives Basse-Pointe from the point of view of staying aptitude. If her high quality allowed her to do great things over intermediate distances (a mile and a half to a mile and five furlongs), Prix Vermeille in 1910, Prix Fille-de-l'Air and Grand Prix de Deauville in 1911, it is especially over long distances that she was at home. As a three-year-old she won by ten lengths the Handicap de la Manche (two miles and a furlong); also by ten lengths the Prix Salverte (two and a half miles). As a four-year-old she was beaten in the three miles and a furlong of the Prix Rainbow only by La Française, and she beat the rest of the field by twenty lengths; besides she took her revenge on La Française in the Prix Gladiateur, when she beat her rival five lengths. Finally we will cite her victory in the Prix du Conseil Municipal, where the top weight which she carried (139¾ pounds) and where the heavy going severely tested her remarkable staying qualities in spite of the comparative shortness (one and a half miles) of the race.

In spite of her beautiful lines, Basse-Pointe is a very small mare; her rival, La Française, of whom we spoke above and who won the Prix du Cadran (two miles and five furlongs), the Prix Rainbow (three miles and a furlong), the Prix la Rochette (two miles and six furlongs), the Prix Florian Kergorlay (two miles and a furlong), was no bigger than she. While these two small and excellent mares were dividing the four-year-old trophies, the best horse of 1911, a year rich in good horses, was

a still smaller horse, As-d'Atout, winner of the Grand Prix and an approved stayer.

Some people have been surprised at these performances. There is, however, nothing surprising in them. As Basse-Pointe, La Française and As-d'Atout had the conformation of stayers, they won all their success at distances above the average, even at very long distances.

If these little horses had had the conformation of pure sprinters, they would not, in spite of their undeniable quality, have been able to win, for they would always have found to beat them a pure sprinter taller than they and consequently favorably handicapped by his height.

The little horse who can win races will then have more or less the model of the stayer. For this very reason his victories will be won over distances exceeding the means of the sprinters and the paucity, if not the absolute lack, of big horses of his model will leave him a free field for winning very fine races.

More of these examples might be given, but we believe that we have indicated sufficiently the characteristics which differentiate the long distance horse from the sprinter, and we think we have made clear the advantages which may accrue from given modifications either of the forehand or of the hindquarter.

We believe ourselves authorized to conclude this study by saying that quality is an attribute by itself; that it can be found in all models; that aptitudes are multiple, and that each one of them corresponds to a best model for its purpose.

This opinion was sustained in an excellent article which appeared in the "Jockey" of January 3, 1913, over the signature "Ignotus."

The author after having studied the somewhat disconcerting results of the racing of 1912 shows, on the contrary, the logic of these results, when there is taken into consideration the aptitude of the various compet-

itors, and he finishes with these wise words, which we permit ourselves to quote textually:

"The results of last year's racing indicate clearly that each distance requires a particular aptitude, and that among competitors of almost equal worth, the best is he who is running over his own distance. If it happens, then, that it is desired by conditions of races, especially to develop certain aptitudes, these necessarily will appear under the model most appropriate and most favorable to their manifestation. There is, therefore, a close co-relation between the conditions of the races, the aptitudes, and the models of horse. Starting out with this fact, if one realizes that the thoroughbred horse is what he is made by racing associations, that as they model him by the conditions of races, so he will reproduce himself in the service horses which he is commissioned to improve, the prime importance of the functions performed by the sporting authorities, whose duty it is to making racing programs is at once understood. The truth is that the fate of breeding is absolutely in the hands of the great racing associations, and that according to their tendencies they can modify at will the trend of the horse production of a nation."

V.

Replies to Criticisms

We shall refer only to articles raising objections to the theories put forth in "Une Foulée de Galop." They reduce themselves to two, one published by the "Sport Universel Illustré" of July 18, 1909, over the signature of its editor, J. Romain; the other published by "Le Jockey" on July 24.

Here we reproduce these articles:

"Colonel Cousté, who at present commands the remount region of Tarbes, has, by his equine works, notably his studies upon 'The Thoroughbred and the Trotter Stud Books' acquired a prominent position among sporting writers. A very short but very substantial pamphlet, just published by Lavauzelle, is not the least interesting of his works! 'Une Foulée de Galop de Course' contains only about thirty pages, but these few lines tend to prove a capital fact: the change of model caused in the modern thoroughbred by short distance racing.

"Our readers will remember M. de Gasté's 'Model and Gaits'; his indictment of the trotter accused of malformation, represented as a monstrous animal, incapable of progressing except at the 'flying-trot,' powerless either to balance himself, or to move at slow gaits and at the gallop.

"Many skilled minds attached but little importance to the ramblings of the author carried away by passion, and that because they found in the high-class thoroughbred the same direction of radii, and the same angular values as in the great trotters. Why call a crime in the half-bred that for which his elder brother was not reproached?

"This is what Colonel Cousté has noted. Struck by seeing so many runners afflicted with an upright shoulder, with a sloping arm, and with an extremely sloping femur, which defects, it appears, were exceptions in the old-time race horse, he has tried to sort out the reasons for this new conformation. It is the fruit of these researches which is presented to us in 'Une Foulée de Galop de Course.'

"We will return later to this most interesting work. It deserves to be examined and discussed, point by point; to be commented upon with corroborative photographs. The author bases his arguments upon chronophotographs by Marey, and especially upon a series of pictures published by Lieutenant-Colonel Gossart which, unfortunately, do not appear in the pamphlet. It would be interesting to reproduce them and to examine them with M. Cousté's text.

"We must be content for the moment with summing up the substance of the pamphlet.

"In studying these chronophotographic series, Colonel Cousté found out that, during the stride of the gallop, which is complete in 19/50 of a second, the velocity of translation of the body—variable as is easily imagined—reaches its maximum when the animal is propelled simultaneously by a hind leg and front leg, that is to say, during the brief duration of the diagonal base.

"On the other hand, this velocity decreases to its minimum during the period of suspension, contrary to the generally accepted opinion.

"The result is, therefore, that to enable him to go as fast as possible, a horse is interested in diminishing his period of suspension. To say that he is interested is naturally a figure of speech, our poor horse being himself incapable of changing his gaits in the desired way.

But where his will and ours are powerless our system of racing has, according to the author, succeeded.

"Short distance races have given birth to a special type, that of the sprinter, whose gallop is choppy with quick and frequently repeated strides and a minimum period of suspension. A gait which carries with it a shoulder but little sloping, a very sloping arm, elbow to the rear, rather short pasterns; a sloping croup, and femur, stifle to the front, and a cut off rump. The general appearance is short, and the four feet are close together.

"Do we not recognize the portrait which was once made of the trotter, of the high-class trotter?

"Well, I am afraid lest this model, which is presented to us as that of the sprinter, be, in the very near future, that of all high-class thoroughbreds.

"It is certain that two-year-old races and short distance races, have been abused by us, although on this road we have been caught and easily passed by our neighbors, the English.

"But neither on this side of the Channel, nor on the other, can there be imputed to these mistakes the changes found, either correctly or incorrectly in the thoroughbred. Colonel Cousté, who is not only an eminent horseman, but a distinguished sportsman, must have lost sight of the fact that since 1780 in England, and 1860 in France, selection has always been made upon the basis of the Derby, that is to say, upon the horse who, in the middle of his three-year-old year, has shown himself to be the best at a mile and a half.

"If this distance is considered insufficient, it has been so for one hundred and thirty years; the grievous effects of this selection should have been felt very long before the present time, and should have affected Fitz-Gladiator, who, in the whole breed, has been represented as the type of rangy stayer with long strides, well bal-

anced, capable of producing perfect chargers, which the present thoroughbred is, more times than not, incapable of doing.

"We cannot see how the abuse of two-year-old racing and of purely sprint racing could have influenced so strangely the general conformation of the thoroughbred, since pure sprinters occupy but a secondary place in the stud, and generally have not produced the sires who perpetuate the breed.

"In going back over the pedigrees of most of the cracks of each generation in France or in England, it is easy to see that from father to father, the really good horses descend from winners of the Derby, and in the female line itself it is descent from blue ribbon holders that is always the best recommendation.

"In our humble opinion the truth is that over short distances, as well as over intermediate or long distances, horses run infinitely faster to-day than formerly. Now an exaggerated slope of the radii, carrying with it long and slow strides, has become detrimental to high speed. This conformation is destined to disappear from sprinters as well as from stayers. The superiority of the latter over the former is that their power of nervous reinforcement, their high quality permits them to last longer than the former at the same pace.

"There are long striding and short striding sprinters as well as stayers.

"Why, since Ténébreuse has been called to our attention should we not evoke the memory of the Prix Gladiateur, when Le Sancy, the very type of the lamented old-time thoroughbred, using his cadenced, long, elastic, strides, stopped like a dog, while the mare, who seemed only to be scratching gravel alongside of him, unfalteringly kept on with her choppy gait, which, however, was far from being that of the sprinter?

" A thousand other examples come to my mind. I can still see Allah, the brother to Ajax, an animal with the most extended lines possible, running at six furlongs, making hardly three strides, while his adversaries were doing four, leaving them as if they were tied to a tree at the start, and being smothered by fatigue, although theoretically he should have expended much less energy than his short striding neighbors, thanks to his restful period of suspension.

It is nevertheless true that, from the saddle horse point of view, the conformation toward which the thoroughbred increasingly is tending is open to criticisms.

" But what is the remedy? Colonel Cousté, like so many others, expresses the desire to see less sacrifices to precocity, to see distances increased, but he expresses these wishes without much hope that they ever will be realized.

" So many considerations are against a radical change ....."

(J. Romain, July 18, 1909.)

(From " Le Jockey.")

Colonel Cousté, formerly of the " Corps des Ecuyers," now commanding the remount region of Tarbes, has just published under the title, " Une Foulée de Galop de Course," a pamphlet, which all those interested in the thoroughbred race will read with the liveliest interest and the greatest benefit. The author is besides not unknown to breeders, and the authority which attaches to his name increase the worth of his new work:

" Using the methods of measurement which M. de Gasté brought into prominence for trotters, he scientifically shows the changes which have come about in the shape and proportions of the race horse. The results

of his investigations on this subject are not new; for a long time practical horsemen have been anxious because the type best adapted to the saddle is not seen so frequently, and have complained that the model is deteriorating. But on account of the scientific methods applied by Colonel Cousté, what had been a pure matter of impression, assumes a much greater importance.

"According to him the changes which he noticed in the skeleton of the horse came from his adaptation to greater and greater speed; he lays the blame for this upon the present system of racing.

"Like many authors of indisputable ability and, as did Professor Barrier, much more positively at the last Horse Congress, he believes that breeding formerly conducted with a view to raising horses adapted to distance racing is now conducted with a view to speed, and it is to this difference of point of view that he attributes the differences he notes in the model. Thirty years ago the construction of the old-time horse made him suitable for running at long distances; his present conformation gives him higher speed, but takes away from him the qualities of equilibrium which make the true saddle horse.

"Succinctly summed up, these are the observations of the distinguished writer. While we bow to the ability of Colonel Cousté concerning the facts noted, we cannot see the same causes as he for the changes in the model. He attributes them to an evolution in the system of racing and in the changing purposes of breeding, while in our opinion, the system of racing, in its principal lines, and the object of the breeders are the same as they were formerly.

"As long ago as one hundred and thirty years in England, and seventy years in France, when the Derbys were established, serious minded breeders have taken these races as the principal goal of their efforts, and it is toward the production of the Derby horse that they have

worked. Other races, those for speed or for stamina, those for two-year-olds, or for old horses, have appeared to them as compensations more or less remunerative, as prizes more or less glorious, but not to compare with the supreme object. In truth, the Derby founded in 1780, the St.-Leger founded in 1776, the Two Thousand Guineas, the Oaks for fillies, like the Prix du Jockey Club since 1836, the Grand Prix since 1863, and the Prix de Diane, since 1843, invariably have been both in England and in France the foundation of the system of racing.

"It is then to the production of a horse capable of winning these races that serious breeders have devoted themselves, and to that end they have in each generation sought after families which have succeeded best in the classics. In England, from 1834, it is the families of Touchstone and Stockwell which have had the preference, and finally in our time those of Galopin and St. Simon.

"With us the best breeds are less clearly fixed; the magnificent influence of the blood of Monarque, Dollar, Vermont, Fitz-Gladiator for some time threw an incomparable brilliancy upon our breeding, but the value of their blood has not been maintained intact. The efforts of our greatest breeders to preserve their precious qualities by inbreeding have not given results, so that recourse again was necessary to reproducers imported from England.

"The complaint is made that we do not find intact the model which we had forty years ago, but that is due wholly to the circumstance that the heirs of the families of those days have been able to preserve the importance of their position only by constantly repeated crossings with new families. To prove this it is sufficient to consult the list of winners of the Grand Prix and of the Prix du Jockey Club.

"If then the principal winners of Lonchamps, Chantilly, and Auteuil agree less in construction with the ideal horse formerly obtained, in our opinion, this evolution can be imputed neither to a change in the system of racing, since the principal basis has not changed; nor to an error on the part of the contemporary breeders since their principal object is the same as that of their predecessors.

"By these remarks we intend in no way to detract from the value of Colonel Cousté's valuable researches. But we think it right to show that the mistake, if there has been one, goes back to the origin of racing and does not lie in the new tendencies."

("Le Jockey," July 24, 1909.)

As is seen, these two articles present exactly the same objections which can be reduced to the following:

For one hundred and thirty years in England and for seventy years in France the efforts of breeders have tended toward the production of a Derby or of a St. Leger horse; it is the winners of these races which have been continually employed as stallions; the pure sprinters have had but an infinitesimal influence on production; if therefore, the results obtained may be criticized, the responsibility for mistakes made must be carried back to the very beginning of racing instead of being ascribed to new tendencies.

After all, the facts are not denied, facts which we were not the first to point out; explanations which we have given of these facts have not been questioned; it is considered sufficient to say "nothing new has been done and tradition has been respected."

We are quite willing to take up the discussion on this ground.

Let us go back, therefore, to 1776 and 1780 when were instituted first the St. Leger, and then the Derby, to say nothing of the Oaks.

Races had been run in England for nearly a hundred years; Flying Childers, Partner, Squirt, Lath, Matchem, Herod, Eclipse, Pot-8-Os, Highflyer, etc., were examples of this period. The tests, generally very hard, varying from three to four miles, had permitted the creation of a race of incomparable stayers; but, it must be admitted, that this race lacked homogeneity.

With the Arab as a common ancestor, though in varying degrees of remoteness, the horses of that period varied much in size; so the English who desired to select for quality, understanding how much small horses, which, perhaps, were intrinsically the best, were disadvantageously handicapped by the shortness of their legs had instituted a scale of weights according to height which remained in force during almost the whole of the eighteenth century.

This scale of weights was graduated from twelve hands to fifteen hands, and varied between seventy pounds and one hundred and fifty-four pounds. (E. Houel, "Les chevaux de pur sang en France et en Angleterre.")

From this document can be seen how small the race horses of that time were. At the end of the eighteenth century their height varied between about 14½ and 15½ hands. Flying-Childers was 14 hands and 3 1-5 inches high, Cartouch was 13 hands 3½ inches, Bay-Malton 15 hands, Eclipse 15 hands and 1 4-5 inches. Not one of them was of a height which would excite interest in the yearlings which we now see at Deauville.

At the time of the institution of the Derby and of the St. Leger, the average height of the runners was fifteen hands. Now can we imagine to ourselves, on the St. Leger course at Doncaster a 15-hand pony built like a pure sprinter, with a straight shoulder, horizontal arm, and sloping croup? However great its quality, this poor caricature of a worthless barb would have been cooked

in half a mile. At that time little animals gifted with the ranginess and the mechanism of stayers were the only ones capable of defending their superiority over the classic distances; distances short compared with the tests employed up to that time, but in view of the height of the animals, quite long enough not to be called bursts of pure speed.

But under the influence of nourishment, of care, of selection, and of climate, the heights increased: Whalebone, Tramp, Newminister, Touchstone were 15½ hands high; Irish-Birdcatcher, Sweetmeat, 15 hands and 3 inches; Melbourne, West Australian, 15 hands 3¼ inches; Surplice, Wild Dayrell 16 hands 1 inch.

In our time the fifteen three horse is a little horse: Bendor, Blue-Green, Carbine, Isinglass, Kendal, Ravensbury, St. Simon were 16 hands ¾ inch; Common Florizel, Persimmon 16 hands 1¾ inches.

With such compass openings, distances became too short. By the very fact of increase in height, the Derby and St. Leger are tending to lose their character as tests of stamina and to become races of pure speed, consequently, the stayer model is no longer indispensable for the competitors.

But it is not only height which reduces distances, there is still quality. We do not attempt to deny that this quality is improving, that forcibly it must improve as a result of selection more and more severe, of progress in the science of breeding and in the methods of training.

It is certain that if we had the extraordinary idea of running percherons, the mile and a half of the Derby would be for them a " Prix Gladiateur " of perhaps mortal severity, and that the competitors would have to have for running this test the qualities, and consequently the model of the stayer.

On the other hand, it is not absurd to foresee that one day, which is perhaps not very far off, a pure sprinter

will, without wearing himself out, gallop over the two and a half miles of the Prix du Cadran with the same action as if he were running a mile dash.

When we weigh these considerations, can we reasonably place upon our forefathers the responsibilities for the results which we deplore to-day? Legislation had by them, was good in their time; for a long time it was sufficient. We had the simple-mindedness to believe that we were respecting tradition when the underlying conditions were changing radically. We stuck to the letter and not to the spirit, and far from recognizing the facts, we have difficulty in explaining the cause. What a service would have been done to breeding if the creators of the classic races had decreed that, for a hundred years, the distances should be increased each year by ten meters!

Increase in height, increase in quality and rigorous selection of individuals having special aptness, were then necessary for the changes which we have just noted to have taken place.

It will be understood that this evolution proceeded very slowly in the beginning and, in fact, we do not think that before the middle of the nineteenth century, a deterioration in the model of the race horse could have been noted even in England. It is enough to recall the names of the animals of that time most celebrated as breeders: West Australian (1850), The Flying Dutchman (1846), Sweetmeat (1842), Wild-Dayrell (1852), New-Minister (1848), Stockwell (1849), Rataplan (1850), King-Tom (1851), Voltigeur (1847).

But once the evolution began, it rapidly increased. The multiplication of short distance races threw into the studs a lot of mares having in varying degrees, the special particularities of aptness, and the model, as well as the mechanism, changed rapidly.

Things did not happen in France in exactly the same way. Our old race of stayers, descending from Emilius, Royal-Oak, Gladiator, Sting . . . for a long time protected by the regulations of the Department of Studs, commenced its evolution but slowly; the first symptoms were noticed under the influence of Dollar, from whom descend nearly all the stayers of to-day, but who really was a transition stallion. Now Dollar was foaled in 1860, and his important produce is found from 1870 to 1885. But as soon as it was decided in France to follow the English mistakes, the evolution proceeded with great rapidity, thanks to the elements already adapted, which had existed for a long time in England and the importation of which was sufficient.

The history of our Grand Prix throws a particularly significant light upon the question.

From 1863, the date of its foundation, to 1879, the Grand Prix was won almost alternatively by English and by French horses. (Nine French and seven English victories.)

From 1880 to 1886 the English had an uninterrupted series of seven victories (we call English the winners of 1883 and 1884, Frontin and Little-Duck, since they were imported *in utero* from England).

From 1887 to 1913 the French won a series of twenty-five victories, interrupted once in 1906 by the victory of the English horse Spearmint.

It would be truly childish to attribute to chance alone facts which present themselves with a character so significant, when the march of the evolution of the thoroughbred in England and France furnished such a plausible explanation of these facts.

From 1863 to 1879 the good English and French horses are about equal at a mile and seven furlongs; that is to say, that they each were capable of showing the measure of their quality at this and at even greater distance, hence

the winners are equally divided between the representatives of the two nations.

But there had begun in England the evolution which was to bring about in the horse an adaptation to shorter distances, and in 1880 we arrive at the moment when this adaptation was perfect for the mile and seven furlongs of this test. Consequently seven consecutive victories for the English.

Still the evolution kept on and beginning with 1887 the mile and seven furlongs of the Grand Prix became too much for the English cracks, and consequently twenty-five consecutive victories for France against one lone English victory (Spearmint, 1906).

Does this mean that the same evolution has not taken place in France? Not at all, but it took place later, and English horses are still a little in the lead in this backward direction. But it is probable that at the present time no horse of the highest quality, either in France or England, is running his proper distance in a race of a mile and seven furlongs. Are there not every year doubts concerning the ability of the greatest cracks to stay the mile and a half of the Derby?

However, the Grand Prix will continue to be run at a mile and seven furlongs, and very soon when the aptitudes of the horses shall have become standardized in France as they have in England, we will see our great race won alternately by an English horse and a French horse exactly as in the beginning.

The horses of the two nations will compete again on equal terms, with this difference, however, that at first they were above their tasks, and soon they will not be up to them.

We have now to explain ourselves by two examples given by the " Sport Universel Illustré," examples which apparently tend to weaken our theories.

"Allah, the brother to Ajax," says Mr. J. Romain, "an animal with the most extended lines possible, was smothered by fatigue at the end of six furlongs, after having run over his horses at the start, and leaving them tied to a tree. . . ."

Never having seen Allah, I will invoke in my defense Mr. J. Romain, himself. In his report of the fifth of August, 1906, the editor of the "Sport Universel Illustré" presents Allah to the public in the following terms after his victory in one of the stakes at St. Cloud:

"Remarkable like many of the produce of his father (Flying-Fox), by the power of his loin, by the length of his hip and the slope of his thigh, with a good body, a low breast and a very long shoulder, he seems to be a little short because his fore legs are brought under the mass as in certain trotters, a deformity which has been called malformation. It appears that this does not keep him from running because, in spite of his horizontal arm, Allah galloped along with magnificent strides."

We think it useless to insist. The attention of the reader is now fixed upon the very detail of conformation which kept Allah from being anything but a sprinter.

Mr. Romain evokes also a memory of the Prix Gladiateur in 1889, in which Le Sancy, "the type of the lamented old-time thoroughbred," after having seemed to beat Ténébreuse by his extended and elastic gait quit before the last third of the race, and let his rival go on with her choppy gait. . . .

No, Le Sancy is not the type of the lamented old thoroughbred, not by a great deal. With his common shoulder, with the shortness of his forward half, in spite of the length of his neck, with his straight, short pasterns, with his short femur and his square rump, this animal of very high quality is essentially the type for intermediate distances. What should we do to him to make a pure

sprinter? Flatten his arm and shorten up his loin (it is the play of his lumbar arch which gave him his brilliant gait). What must we do to him to make a stayer of him? Change nearly all his slopes.

How different from the conformation of Ténébreuse, admirably constructed as a stayer in her entirety and in all of her details!

And what a difference in the careers of the two runners!

Le Sancy, unbeatable at a mile and a quarter, to the extent that he scared everybody out and had several walkovers at that distance, won several good victories at a mile and 9-16, among others the Grand Prix de Deauville; he tried but once at a mile and seven furlongs the Grand Prix de Paris won by Ténébreuse, in which he was not even placed, and it was with such a record that he dared, in 1889, to face Ténébreuse in the Prix Gladiateur. Ténébreuse, winner of the Grand Prix and of all her three-year-old races, except the Prix de Diane; Ténébreuse, who proved her special aptitude by winning the Cadran, Rainbow, and Cesarewitch, and Gladiateur in 1888! In truth, the race was won before it started, and it is hard to understand the mental process of those who started him in such a race and of the players who made Le Sancy favorite.

All sportsmen of a certain age were familiar with the peculiarities of Le Sancy's conformation; we cannot do better than to refer those who did not know this illustrious horse to the valuable collection of the "Sport Universel Illustré." In its numbers of May 26 and June 2, 1907, on the subject of the role of Maintenon in the stud, this paper gives particularly instructive photographs of Atlantic, of Le Sancy, and of Le Sagittaire. They can convince themselves that the portrait that we have drawn of Le Sancy is absolutely correct. They will also notice,

by examining the picture of Le Sagittaire, the skeletonic changes which differentiate him from his father, and which permitted him to show remarkable staying qualities behind an animal as good as Omnium II.

H. Cousté.

Pau, March 20, 1914.

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